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ADVANCED WASTEWATER TREATMENT FACILITIES FOR SOUTHEASTERN MICHI--ETC(U)

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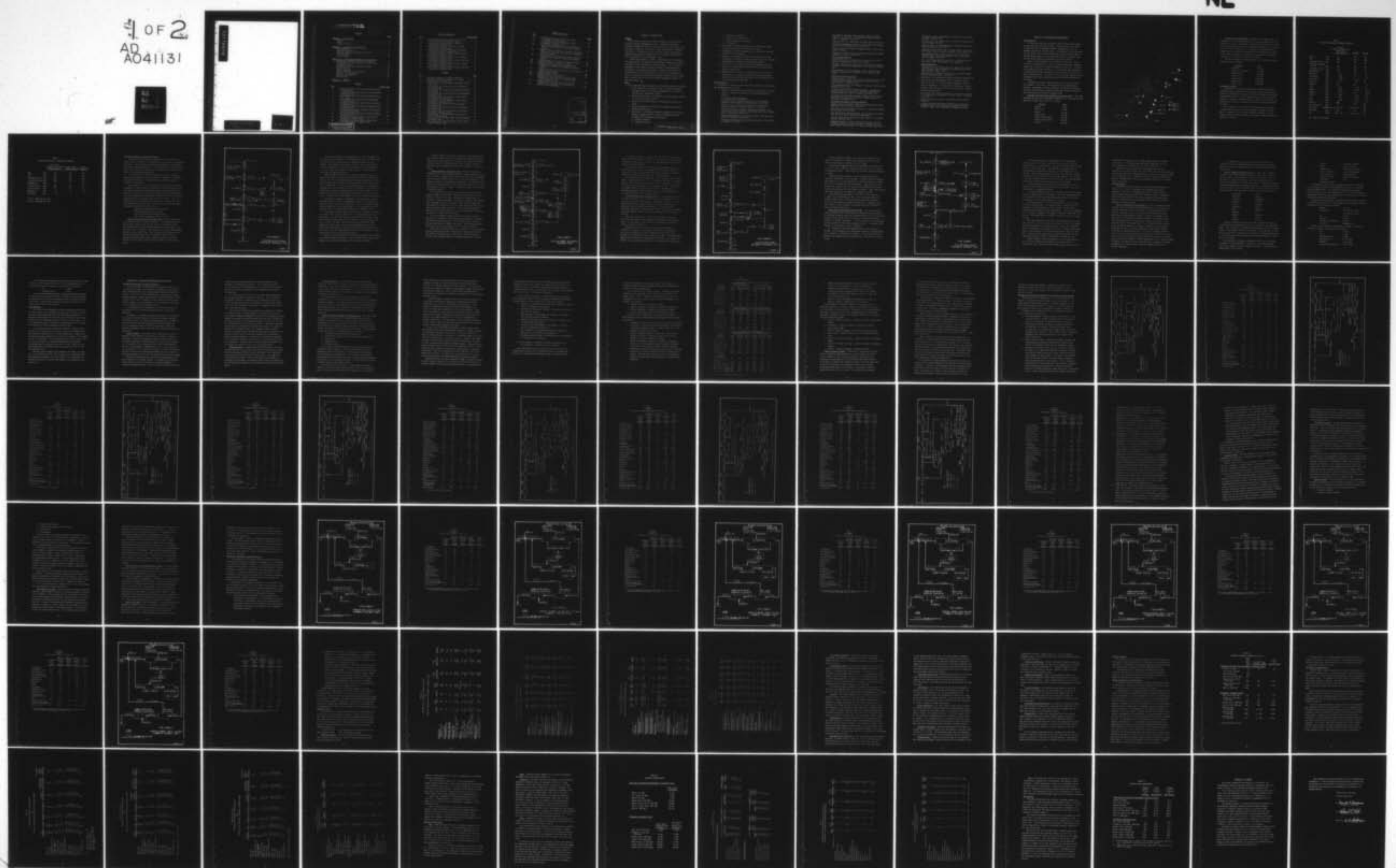

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SECTION I - INTRODUCTION

Purpose

This report delineates one major element in the Southeastern Michigan Wastewater Management Program. Presented herein are schematic designs and cost data for facilities to treat domestic and industrial wastewater, and surface runoff resulting from precipitation events. Facilities have been outlined to meet both present Michigan water quality standards and more stringent criteria which may be applicable in the foreseeable future.

Conventional primary, secondary, and advanced waste treatment processes provide one approach to maintaining a high quality aquatic environment in the southeastern Michigan region. The information contained in this report provides the basis for evaluating this alternative for wastewater renovation. Further, the information is presented on a unit process basis so that it can be applied in various combinations with physical-chemical or land disposal arrangements to arrive at the most cost effective management program for the study region.

Scope

This study and report encompasses the following specific elements:

1. Field inspection and office review of existing wastewater treatment sites and facilities designated for inclusion in the Wastewater Management Program.
2. Review and evaluation of wastewater flows and quality profiles for each designated location.
3. Review of the current State of Michigan water quality criteria.
4. Review and analysis of the Corps of Engineers prescribed effluent quality goals.
5. Derivation of alternative treatment schematics to meet both present Michigan and future Corps of Engineers criteria including the following unit processes:
    a. Primary treatment.
    b. Phosphate removal

c. Biological treatment.

d. Advanced waste treatment.

e. Sludge handling and disposal.

f. Disinfection.

6. Development of capital and annual cost estimating curves for each unit process included in the study.
7. Adaptation of treatment approaches to incorporate existing facilities where possible.
8. Analysis of treatment alternatives with regard to costs, reliability, flexibility, power, chemical, and other resource requirements, and regional environmental impacts.
9. Selection of the preferred treatment arrangement for each location to handle the specified volume of sanitary wastewater or storm runoff.
10. Summarization of costs, on a unit process basis, for the final plan at each location including total and amortized capital cost, annualized replacement cost, and annual operation and maintenance expenses.

Sources of Data

Following are sources of data upon which evaluations, conclusions, and recommendations are based.

1. Reports, studies and other information from federal and state agencies, individual communities, and planning bodies as follows:

U. S. Army Corps of Engineers

"Alternatives for Managing Wastewater for Southeastern Michigan, Summary Report, Detroit District, July 1971."

"Alternatives for Managing Wastewater for Southeastern Michigan, Appendices, Detroit District, July 1971."

"A Pilot Wastewater Management Program for Chicago, Cleveland, Detroit, San Francisco, and the Merrimack Basin, Office, Chief of Engineers, March 1971."

"Wastewater Management Program, Feasibility Study Procedure, Office of Engineers, March 1971."

"Wastewater Management Program Study Procedure, Office, Chief of Engineers, May 1972."

"Southeastern Michigan Water Resources Study, Technical Paper No. 3, Gazetteer of the Black River Basin, Detroit Corps of Engineers, June 1969."

"Rainfall Data for Southeastern Michigan, Detroit District."

"Wastewater Management Program - Program and Study Guidance, Office, Chief of Engineers, November 1971."

"Detroit District Wastewater Management Survey Scope Study, Detroit District."

"Analysis of Detroit Metropolitan Water Department's Sewage Treatment Facilities, April 1972."

Other Federal Agencies

"Interim Report of the Secretary of the Army on the Pilot Wastewater Management Program, August 1971."

"Geologic and Hydrologic Studies of Three Areas in Southeast Michigan, United States Department of the Interior, January 1972."

"Water Resource Data for Michigan, Part 1 Surface Water Records, United States Department of the Interior, 1966-1970."

State and Interstate Agencies

"Summary Report on Pollution of the St. Marys River, St. Clair River and Detroit River, International Joint Commission Advisory Board, September 1968."

"Use Designation Areas for Michigan's Intrastate Water Quality Standards, March 1969."

"Plans for Water Quality Management Phase I, Southeastern Michigan Area, Water Resources Commission, Department of Natural Resources, State of Michigan, September 1971."

"Southeast Michigan Regional Water, Sewage and Storm Drainage Facilities and Plans, Southeast Michigan Council of Governments, November 1971."

Municipal and Regional Treatment Agencies

"Detroit Water Development Program for Southeastern Michigan 1966-2000, City of Detroit, July 1966."

"Pollution Control Program for the Detroit Regional Watershed, Detroit Water Service, 1966."

"The 119th Annual Operating Report for the Fiscal Year Ended June 30, 1971, Detroit Metro Water Department."

"Detroit Metro Water Department Progress Report on Pollution Control, February 1971."

"Engineering Report on Waste Treatment Facilities for City of Monroe, Monroe Township, Frenchtown Township, and the Monroe Paper Industry, County of Monroe, Michigan, May 1967."

"Preliminary Report on Wastewater Treatment for Port Huron, Michigan, February 1969."

"Official Pollution Control Plan for Port Huron Metropolitan Area Michigan, July 1970."

"Data for Basis of Design-Wastewater Treatment Plant, Port Huron, Michigan, May 24, 1972."

"Addendum to March 1967 Bases of Design, Wayne County Down River Sewage Disposal System, Wyandotte Plant, January 1971."

"Engineering Report on Proposed Expansion of Wastewater Treatment Plant Serving Ira Township, Clay Township, and City of Algonac, June 1971."

"St. Clair Sewage Disposal System No. 3, Wastewater Treatment Plant, East China Township, 1972 Expansion."

Planning Agencies

"Community Facilities Plan, Water and Sewage Plan, Recreation Plan and County Buildings Plan, Lenawee County Planning Commission, March 1970."

"Background for Planning, Lenawee County, Michigan Comprehensive Planning Program, June 1969."

2. Discussions with wastewater treatment equipment manufacturers.
3. Discussions and correspondence with personnel from the Detroit District, U. S. Army Corps of Engineers; Office, Chief of Engineers U. S. Army Corps of Engineers; State of Michigan Water Resources Commission; and existing treatment plant operating staffs.
4. Discussions with special consultant to the Detroit District U. S. Army Corps of Engineers, Dr. Walter Weber, University of Michigan.
5. Review of technical reports, publications and periodical literature.
6. A report entitled "Wastewater Treatment Unit Processes, Estimating Costs 1972," prepared by Stanley Consultants as Phase I input to this Wastewater Management Program.

SECTION II - BACKGROUND AND METHODOLOGY

Plan Selection

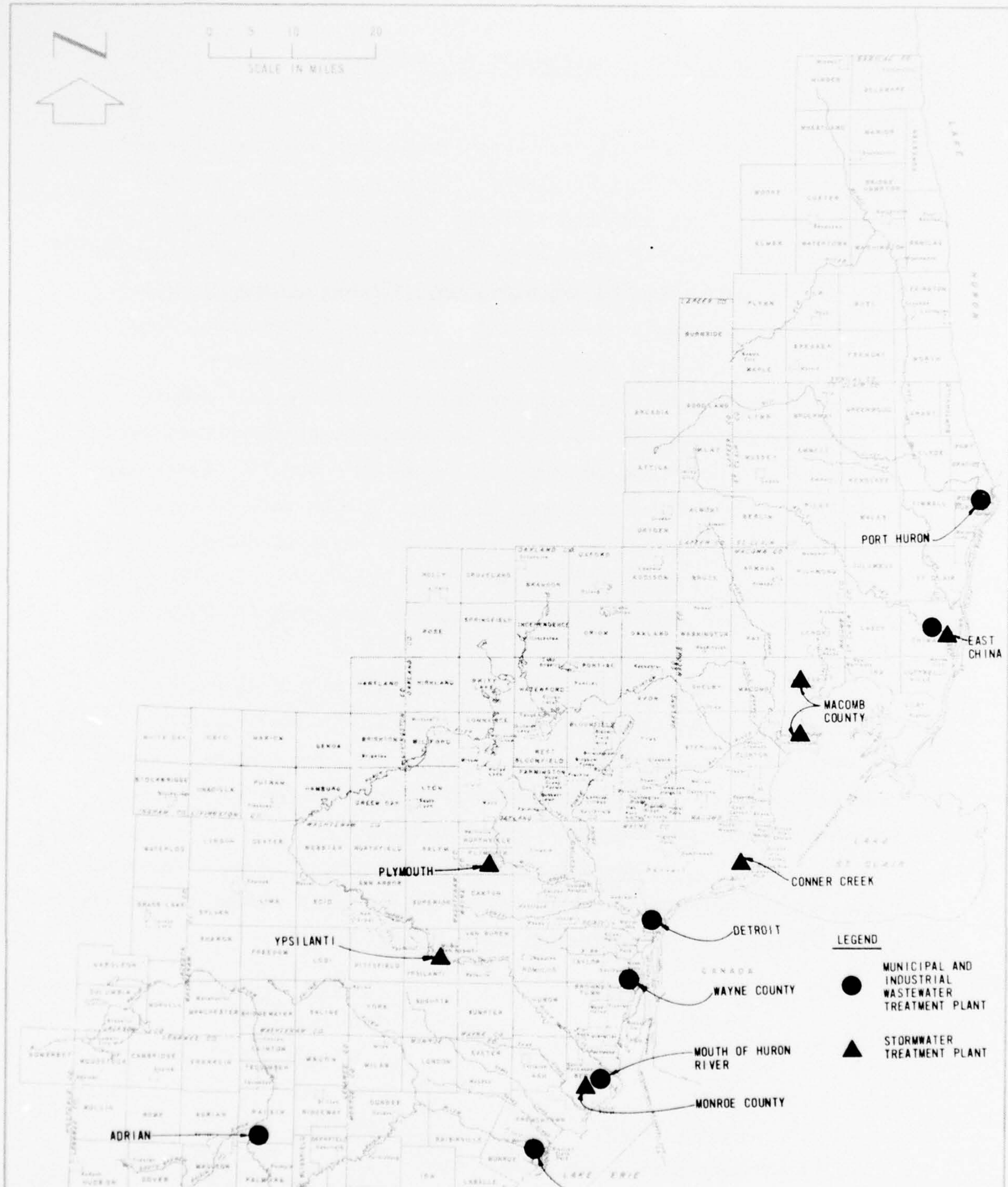
As the first phase of this study, unit processes were planned for ten wastewater treatment plants. These plants were designed to meet the State of Michigan effluent standards and Corps of Engineers prescribed effluent goals. Flow schematics were developed for each plant to meet the two different effluent criteria and for the specified volumes of municipal-industrial and stormwater flow. Several sludge handling arrangements were also evaluated.

Based on data presented to the Detroit District as a result of Phase I investigations, a total of fourteen wastewater treatment plants were selected for further refinement in Phase II. Locations of the plants are shown in Figure 1. Seven plants were designated to treat municipal and industrial wastes and seven plants as stormwater treatment plants. At several of the locations, different plant arrangements have been considered to handle specified alternative flow rates.

Wastewater collection facilities were not within the scope of this segment of the study. Facilities which were investigated include: preliminary, primary, secondary, and advanced wastewater treatment unit processes; sludge treatment and disposal approaches; and inter-plant and effluent discharge piping.

Municipal and Industrial Wastewater Treatment Plants - The seven municipal and industrial wastewater treatment plant locations and the specified average flow rates are as follows:

Location	Flow
Adrian	12 mgd
Port Huron	24 mgd
Monroe	40 mgd
Wayne County	125 mgd
Mouth of Huron River	400 mgd
Mouth of Huron River	525 mgd
Detroit	806 mgd



PROPOSED TREATMENT PLANT LOCATIONS
SOUTHEASTERN MICHIGAN AREA

FIGURE 1

Stormwater Treatment Plants - Stormwater treatment plants were designated to treat urban runoff and wet weather overflow from combined sewer systems. Stormwater storage facilities will be provided to reduce peak flow rates to the treatment plants and also to provide a more uniform treatment rate. The analysis presented herein considers only the facilities necessary to treat stormwater as pumped from storage; evaluation of collection, transmission, and storage facilities is outside the scope of this study.

The seven stormwater treatment plants and the specified treatment rates are as follows:

Location	Flow
East China	125 mgd
Plymouth or Ypsilanti	225 mgd
Macomb County	400 mgd
Conner Creek	600 mgd
Monroe County	1,000 mgd
Conner Creek	1,200 mgd
Monroe County	1,400 mgd

Wastewater Profiles

Evaluation of available municipal and industrial wastewater characteristics and projections of current trends in water use and industrial pretreatment practices have been considered in establishing wastewater profiles for the proposed plants in the study area. Average dry weather constituent profiles used for the design of the municipal and industrial wastewater treatment plants are presented in Table 1.

The assumption has been made that the equivalent of primary treatment will be achieved in the stormwater storage facilities prior to pumping to the proposed treatment facilities. The constituent profiles used for design of stormwater treatment plants are presented in Table 2.

TABLE 1

DRY WEATHER SANITARY WASTEWATER PROFILES

		Detroit Mouth of Huron River Wayne County Port Huron	Monroe	Adrian
BOD_5	mg/l	132	174	225
COD	mg/l	350	348	500
Suspended Solids	mg/l	226	143	300
Volatile Suspended Solids	mg/l	158	100	250
Settleable Solids	mg/l	129	136	NA
Phosphates-P	mg/l	11.7	13	13
Ammonia-N	mg/l	7.5	11.3	10
Nitrates-N	mg/l	0.051	NA	0.4
Nitrites-N	mg/l	0.002	0.011	NA
Organic-N	mg/l	13.3	3.1	15
Cyanide	mg/l	NA	NA	1.0
Iron	mg/l	8.03	1.48	10
Copper	mg/l	0.36	0.07	0.5
Cadmium	mg/l	0.015	NA	0.015
Nickle	mg/l	0.52	0.01	0.5
Zinc	mg/l	0.44	0.05	0.5
Lead	mg/l	0.16	0.13	0.2
Phenols	µg/l	588	40	NA
Oil and Grease	mg/l	71	43	45
Coliforms	MPN/100 ml	21.6×10^6	51.6×10^6	NA
Chlorides	mg/l	184	NA	NA
pH	range	6.8 - 7.5	6.6 - 7.4	NA

NA - Data not available.

TABLE 2

STORMWATER PROFILES AS PUMPED FROM STORAGE

		East China Plymouth or Ypsilanti Macomb County	Conner Creek Monroe County (1)	Monroe County (2)
BOD_5	mg/l	30	45	40
COD	mg/l	90	120	100
Suspended Solids	mg/l	400	250	300
Settleable Solids	mg/l	100	75	75
Phosphates-P	mg/l	6	7	6.5
Volatile Solids	mg/l	160	125	120
Oil and Grease	mg/l	20	30	25
Ammonia-N	mg/l	3	7	4.5
Nitrates-N	mg/l	1.5	1	1

(1) For 1,000 mgd flow rate.

(2) For 1,400 mgd flow rate.

Existing Wastewater Treatment Facilities

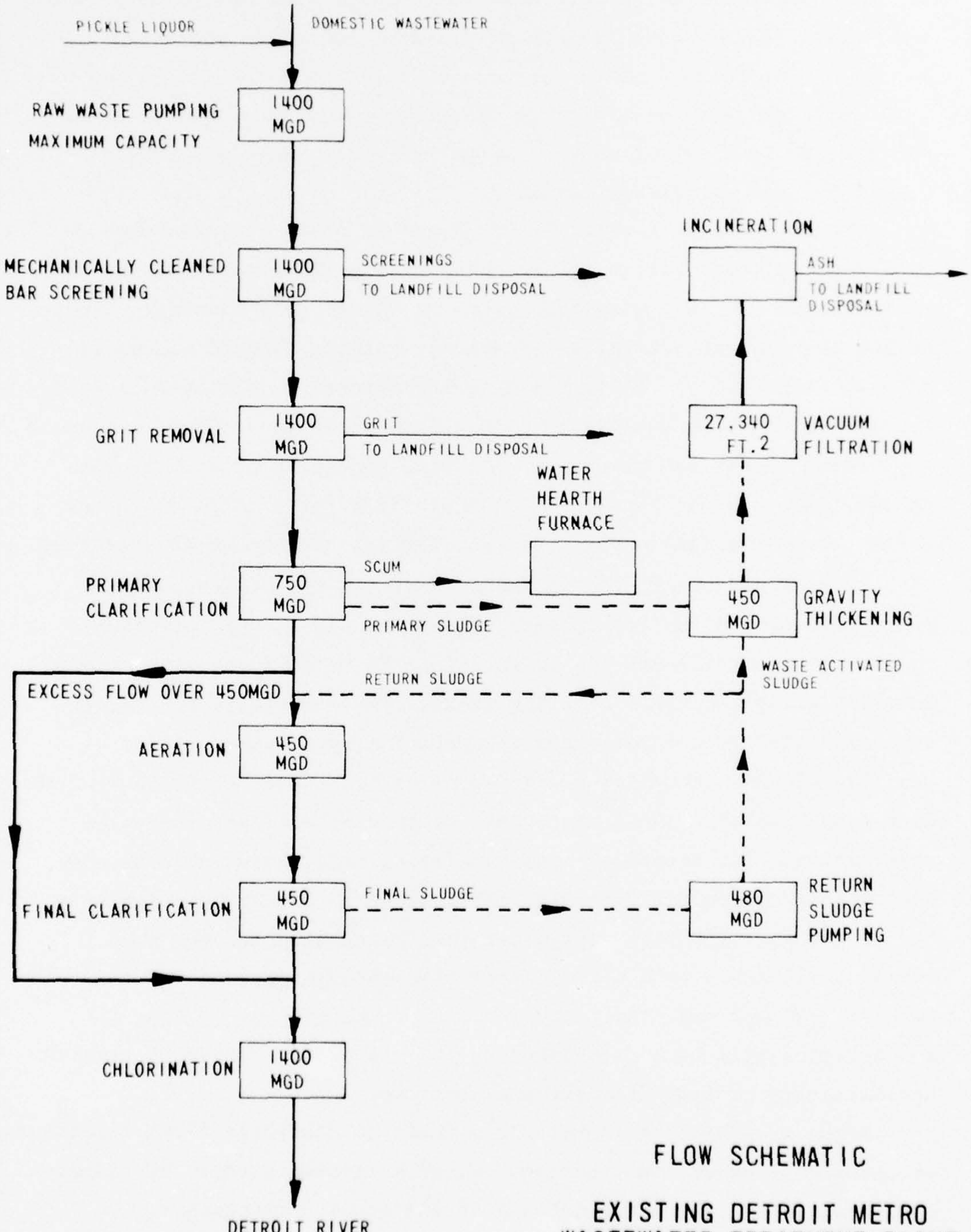
The municipal and industrial wastewater treatment plants at Adrian and at the Mouth of the Huron River, as proposed, are completely new plants. The remaining four plants are designed to take maximum advantage of existing facilities. An evaluation has been made of each plant to determine the feasibility of fitting existing unit processes into the new treatment arrangements.

At the present time there are no major facilities within the study area exclusively for the treatment of stormwater. Therefore, all proposed stormwater treatment plants have been developed as entirely new facilities.

For the purpose of this investigation, existing facilities are designated as those presently in operation, those now under construction, and those which are planned and will be constructed prior to about 1975. Flow schematics and descriptions of existing facilities have been developed from information obtained from field inspections, design outlines, and detailed plans and specifications. Data is presented for the plants at the following four locations which have been incorporated into the master plan for municipal and industrial wastewater treatment for the study area.

Detroit Metro Wastewater Treatment Plant
Monroe Wastewater Treatment Plant
Port Huron Wastewater Treatment Plant
Wayne County Wastewater Treatment Plant

Detroit Metro Wastewater Treatment Plant - A flow schematic of the existing facility is shown in Figure 2. Raw wastewater arrives at the plant through 12 and 16-foot diameter interceptor sewers. The average daily flow has recently been about 750 mgd with a maximum daily flow of 1,400 mgd. Peak daily rates of about 900 mgd occur exclusive of wet weather flow. Two 115 mgd, four 150 mgd, and two 180 mgd centrifugal pumps lift the wastewater about 40 feet to mechanically cleaned bar screens. Eight constant velocity grit chambers, 125 feet long, with mechanical scrapers, follow the bar racks.



FLOW SCHEMATIC

EXISTING DETROIT METRO
WASTEWATER TREATMENT PLANT

FIGURE 2

Primary sedimentation is accomplished in 12 old rectangular and two new circular clarifiers. Each rectangular tank is 243 feet long with seven 14-foot wide flights for sludge collection and scum removal. The average water depth is 14 feet. The two new primary circular clarifiers are 250 feet in diameter with a sidewater depth of 11 feet and a center depth of about 28 feet. They are center feed type with peripheral weirs.

Primary sludge of about 0.8 to 1 mgd is presently dewatered on twelve cloth media vacuum filters each with a 505 square foot area. Polymers are the only chemicals used for sludge conditioning. Sludge drying lagoons are available for standby holding, should vacuum filters be inoperative. Filter cake is incinerated in six incinerators equipped with wet scrubbers to control air pollution. Construction is proceeding on sixteen new vacuum filters, each with an area of 754 square feet, and with building space provided for a total of 20 new units. Construction is also underway for six new sludge incinerators.

An expansion currently is underway at the Metro plant, costing approximately $200 million. Improvements consist of the previously mentioned vacuum filters and incinerators as well as activated sludge aeration tanks and final settling tanks. It is anticipated that the expansion will be completed and in operation by November, 1973.

The planned activated sludge aeration tanks are being constructed in a manner which permits comparison of conventional aeration with oxygenation. Two identical tanks are being constructed side by side. One, utilizing conventional air, is designed as a step aeration unit and is rated at 150 mgd. The other tank is constructed for pure oxygen application with a four stage flow-through pattern and is rated at 300 mgd capacity. The aeration tanks will be 30 feet deep and aeration will be accomplished by the use of air diffusers located approximately 15 feet from the tank bottoms.

Eight new 200-foot diameter rim feed-rim discharge final clarifiers are presently under construction. Waste activated sludge and primary sludge will be mixed and thickened in six gravity thickeners.

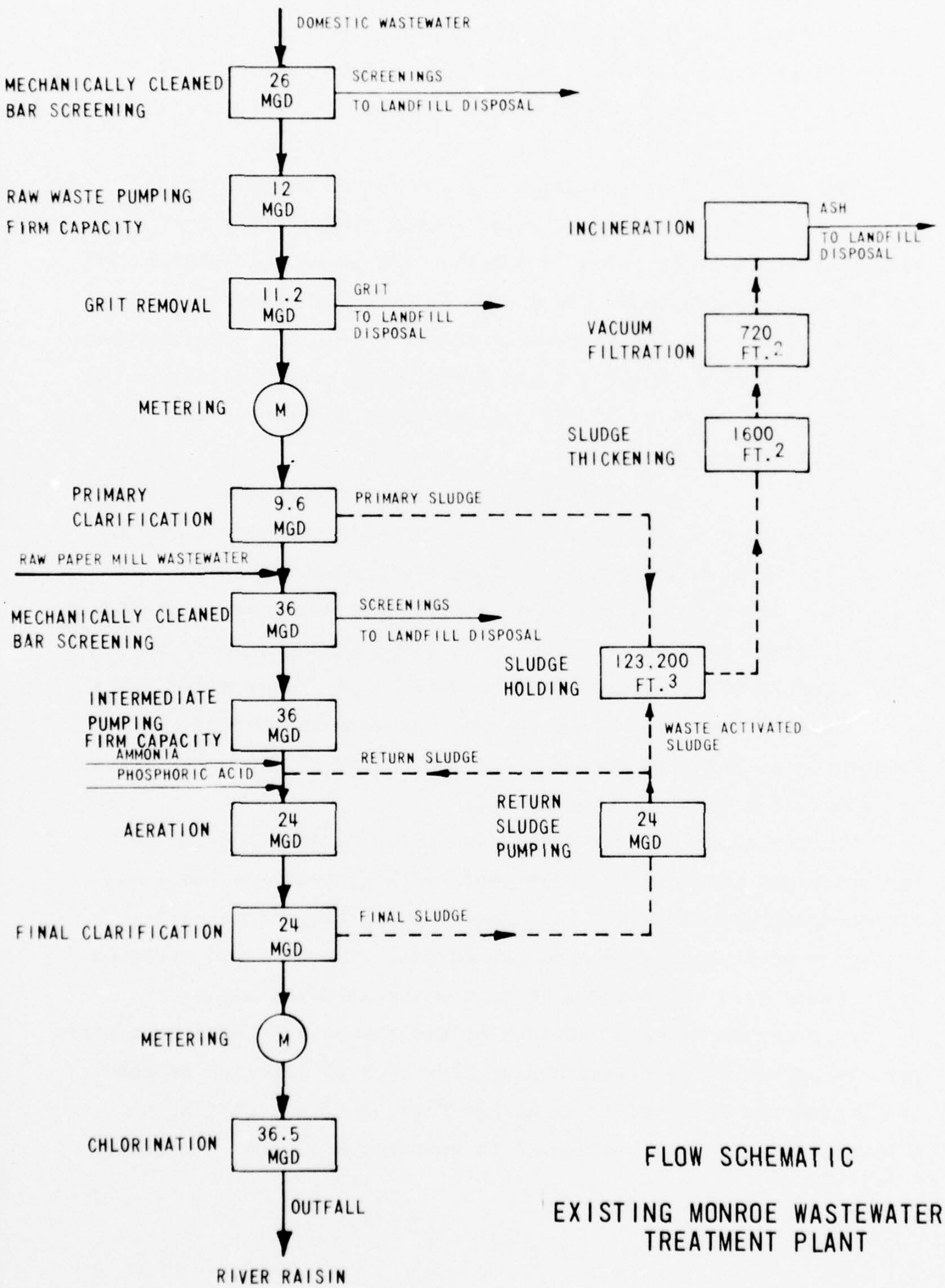
Primary effluent from the existing plant is chlorinated with the effluent conduit to the Detroit River providing the required contact time. New chlorination facilities are being constructed that will provide 15 minutes contact for a flow of 1,400 mgd. Effluent from the expanded plant will be discharged to the River Rouge.

Monroe Wastewater Treatment Plant - Monroe is completing construction of a new secondary (activated sludge) treatment facility to treat a combination of domestic and paper mill wastewaters. The old primary treatment plant will be used for treatment of the domestic portion of the wastewater stream only. The domestic wastewater flow averages between 5 and 6 mgd while paper mill flows are anticipated to be 16 to 17 mgd. A schematic diagram of the facility is shown in Figure 3.

At the old primary facility, raw domestic wastewater first passes through a mechanically cleaned bar screen sized to handle hydraulic flows up to 26 mgd. Screenings are hauled away to a landfill. Screened wastewater is lifted to a detritor grit chamber with a maximum capacity of 11.2 mgd. Three constant speed raw waste pumps with capacities of 2, 4, and 6 mgd are provided along with one 6 mgd variable speed unit. Flow is metered through a venturi tube, prior to passing to two circular primary clarifiers, designed for a total flow of 9.6 mgd.

The new secondary treatment facilities recently placed in operation are designed to treat paper mill wastewaters along with the domestic primary effluent. The combined flow first passes through a mechanically cleaned bar screen. Three 18 mgd variable speed pumps lift the wastewater to the six aeration basins.

Each aeration basin consists of two chambers. The flow pattern permits operation as either a plug flow or step aeration process. The basins are designed for a 24 mgd flow, a detention time of 6 hours, and a design loading of 48 pounds BOD_5/1,000 cu ft/day.



FLOW SCHEMATIC

EXISTING MONROE WASTEWATER TREATMENT PLANT

FIGURE 3

Four final clarifiers are provided, each 105 feet in diameter with a side water depth of 12 feet. A chlorine contact tank provides 15 minutes detention for a flow of 36.5 mgd, prior to effluent discharge to the River Raisin.

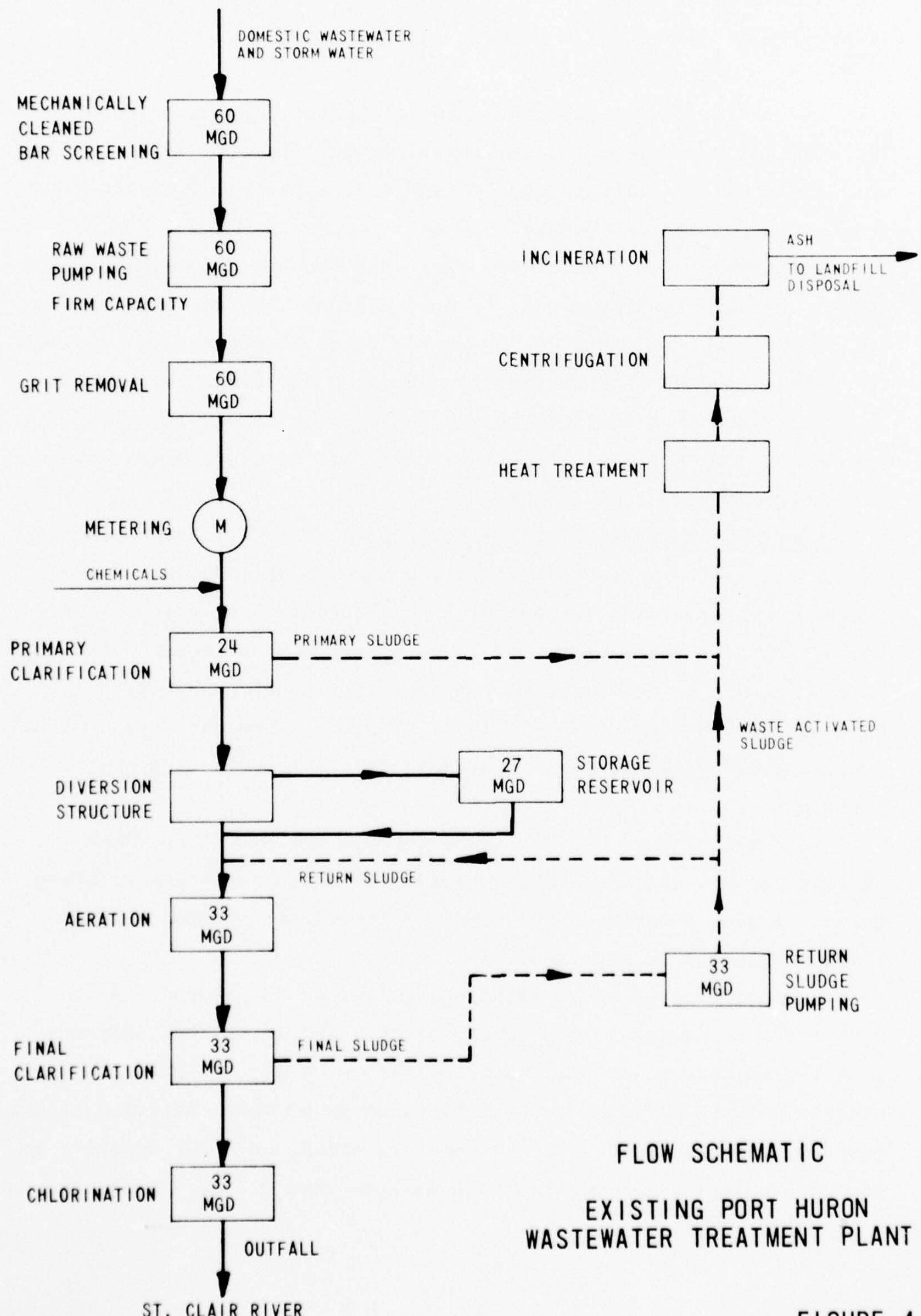
Two flotation units, of the partial pressurization type, by Rex Chainbelt, are used for thickening waste activated sludge. The units, each with a surface area of 800 square feet, are expected to thicken the waste activated sludge to 4 percent solids.

Existing old anaerobic digesters will be used as sludge holding tanks. Sludge dewatering will be accomplished with two coil vacuum filters with a total area of 720 square feet. Equipment is provided for sludge conditioning with ferric chloride and lime. Sludge will be incinerated in a multiple-hearth furnace, equipped with wet scrubbers, presently in the design stage. It is anticipated that the incinerator will be in operation in 1974.

Port Huron Wastewater Treatment Plant - The Port Huron plant is located on the bank of the St. Clair River at the junction of the Black River, several miles south of Lake Huron. This site is just downstream from the downtown business area and is surrounded by commercial and residential establishments. The plant serves a Port Huron population of approximately 40,000. The City has combined storm and sanitary sewers with by-pass structures for storm water overflow.

Bids were opened May 24, 1972, for new secondary treatment facilities that also include remodeling of portions of the existing plant. A flow diagram of the facility including proposed modifications is shown in Figure 4.

Extensive revision to existing facilities is planned. A contract was awarded in the spring of 1972 and it is anticipated that the new expansion will be in operation by late 1975. Bar screens will be modified to pass flows up to 60 mgd. Existing electric pumps will be replaced with new pumps to bring the total capacity to 60 mgd. Existing gas engine pumps will be retained as standby units.



FLOW SCHEMATIC

EXISTING PORT HURON WASTEWATER TREATMENT PLANT

FIGURE 4

The existing grit removal facilities will be replaced with three new aerated grit chambers with mechanical scum and grease removal facilities for a maximum flow of 60 mgd.

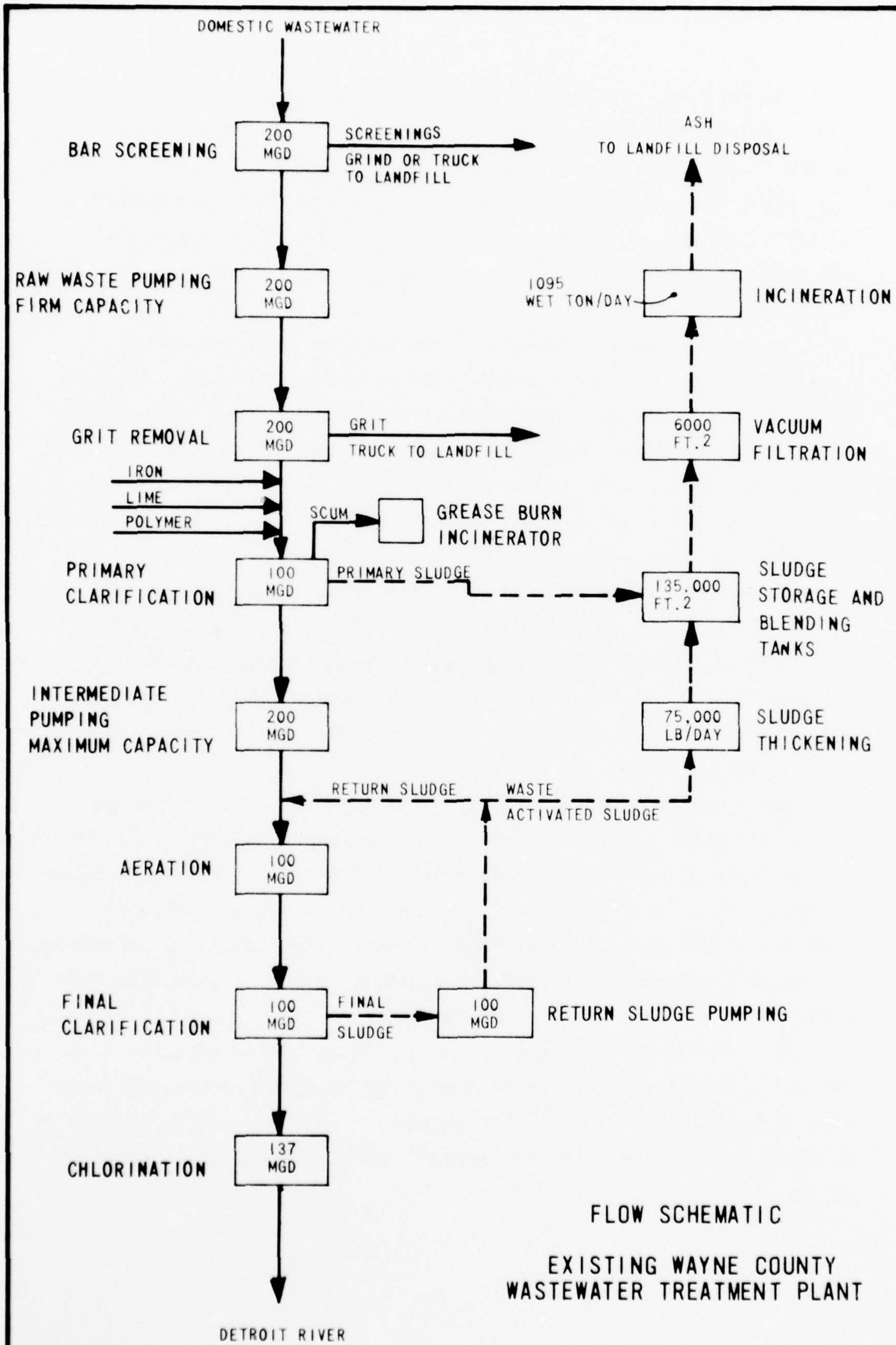
Eight new rectangular primary settling tanks will provide for a flow of 12 mgd. Chemical treatment facilities will be provided for phosphate removal. This will bring the total treatment capacity to 24 mgd.

Maximum hydraulic capacity of the preliminary and primary treatment system will be about 60 mgd. A primary effluent reservoir with capacity of 6 million gallons will reduce the peak wet weather flow to the secondary portion of the plant. High flows from 33 to 60 mgd will be diverted to the basin and then pumped back through the aeration tanks as the flow returns to normal. Three step-aeration tanks will provide for treatment of a maximum of 33 mgd.

Three final settling tanks will provide a total capacity of 33 mgd at two hours detention time. Waste activated sludge and primary sludge will be stored in the existing sludge digesters which will be converted to sludge holding tanks. Sludge treatment will consist of heat treatment, centrifugation, and incineration using a fluidized bed reactor.

Wayne County Wastewater Treatment Plant - The existing Wayne County Treatment Plant provides primary treatment and chlorination. The existing treatment plant was enlarged during 1971 and is presently designed for an average flow of 100 mgd with a maximum hydraulic capacity of 200 mgd. Expansion in the near future will add secondary treatment along with 80 percent phosphate removal. A schematic flow diagram of the facility is shown in Figure 5.

Bar screens and raw waste pumping provide a firm capacity of 200 mgd. The screenings can be ground and returned to the wastewater flow or hauled to a landfill for disposal. Grit is removed in two detritor grit chambers and two aerated units. Each unit is rated at 50 mgd.



FLOW SCHEMATIC

EXISTING WAYNE COUNTY WASTEWATER TREATMENT PLANT

FIGURE 5

Primary sedimentation is accomplished in six rectangular settling tanks. Each tank is 80 feet wide, 146 feet long, and 12 feet deep for a total volume of 6.3 million gallons and a surface area of 70,000 square feet. This provides an overflow rate of 1,430 gallons per square foot per day at the average flow rate of 100 mgd. Primary effluent presently flows into a chlorine contact chamber with a total volume of 1.43 million gallons. This provides a 15 minute contact time for a flow of 137 mgd. The existing plant also has an incinerator with a capacity of 215 tons/day.

Proposed treatment facilities have been designed to treat primary effluent that has been chemically treated with iron, lime, and polymer for phosphorous removal.

A low lift pumping station will be added to lift the wastewater to the secondary portion of the plant. Two fixed speed pumps rated at 50 mgd each and two variable speed pumps rated at 50 mgd each will provide a firm pumping capacity of 150 mgd.

Secondary treatment will be accomplished with a pure oxygen activated sludge process. The aeration tank is designed for an average flow of 100 mgd and is 25 feet deep x 180 feet long x 180 feet wide, divided into four compartments. The tank is designed for a volumetric loading of 102 pounds of BOD_5 per 1,000 cubic feet per day. The oxygen plant is designed to produce 40 tons of oxygen per day.

Four final clarifiers, each 163 feet in diameter, with a side water depth of 13.4 feet, and a total surface area of 83,200 square feet are designed for a detention time of 2 hours and an overflow rate of 1,200 gallons per square foot per day. Return sludge pumping is accomplished by four variable speed pumps rated at 15 mgd each. Waste activated sludge will be pumped into sludge thickening tanks designed to handle 75,000 pounds of sludge per day.

Primary sludge is presently pumped to two 40 foot diameter x 25.5 foot deep sludge storage tanks with a total volume of 54,000 cubic feet. Three additional sludge storage tanks will be

constructed to bring the total sludge storage volume to 135,000 cubic feet. The thickened waste activated sludge and the primary sludge will be blended prior to vacuum filtration.

Eight new vacuum filters will be installed with a total surface area of 6,000 square feet. The filter cake will be incinerated with the ash hauled to landfill disposal. Four new incinerators, rated at 220 tons each, will be installed. With the existing incinerator kept as a standby unit, the total incinerator capacity will be 1,095 (wet) tons per day.

Effluent Quality

Wastewater treatment facilities were initially evaluated with respect to both Corps of Engineers and Michigan water quality standards. The Corps of Engineers prescribed effluent goals are more stringent than present State of Michigan criteria. Therefore, during the final phase of this study, wastewater treatment facilities, as outlined herein, were designed only to meet the Corps of Engineers effluent criteria.

State of Michigan Effluent Criteria - State of Michigan effluent criteria varies from plant to plant depending upon the location and the receiving body of water into which the plant effluent is discharged. Michigan criteria for the Port Huron and Mouth of the Huron River plants presently require a minimum of secondary treatment and 80 to 90 percent phosphorous removal. In addition, limits have been established for heavy metals, cyanide, and phenol in the effluent from the Port Huron Plant. For the Detroit plant, approximately 80 percent removal of the BOD_5, suspended solids, and oils, 94 percent removal of soluble phosphorous, and 84 percent removal of ammonia is currently specified. The State of Michigan effluent criteria for the Adrian wastewater treatment plant specifies the equivalent of 98 percent removal of BOD_5, 95 percent removal of suspended solids, 80 percent removal of soluble phosphorous, and 73 percent removal of ammonia. In addition, limits have been set at Adrian for effluent concentrations of heavy metals, dissolved oxygen, cyanide, and coliform organisms.

At the present time, the State of Michigan does not have effluent criteria for stormwater treatment facilities; standards similar to those for sanitary wastewater treatment facilities have been applied.

Corps of Engineers Effluent Criteria - The Corps of Engineers initially established effluent criteria for this study in three classifications. Classification I applies to substances which must be absent or completely removed. This implies reduction to the limit of detectability or to the lowest level attainable by presently available advanced waste treatment technology. Constituents included in Classification I are listed below with asterisks identifying those items reported in the wastewater profiles utilized for this study.

Pesticides	Lead*
Phenols*	Mercury
Cyanides*	Molybdenum
Antimony	Nickle*
Barium	Selenium
Beryllium	Silver
Boron	Thallium
Cadmium*	Tin
Chromium	Titanium
Cobalt	Zinc*
Copper*	Arsenic

Treatment alternatives which have been considered are capable of reducing all constituents listed in the profiles to the specified goals. The alternatives considered can also reduce all other Classification I constituents, which are not present in the profiles, to the desired level with the exception of pesticides, chromium, and mercury. It will be necessary that discharges of these constituents be eliminated at the source.

Classification II indicates substances which must be virtually eliminated from the wastewater or reduced to the lowest possible level using standard accepted treatment processes. Classification II constituents are as follows:

Viruses	Settleable Solids*
BOD_5*	Volatile Solids*
Surfactants	Total Organic Carbon
Fecal Streptococci	Total Oxygen Demand
Taste and Odors	Gamma Radiation
Oil and Grease*	Synthetic Organics
Floatables	COD*
Suspended Solids*	

The treatment alternatives considered are capable of reducing all constituents present in the wastewater profiles to the desired virtually absent level. The treatment alternatives should also achieve compliance with the desired goals for all other constituents except gamma radiation, where removal would be limited to the fraction associated with suspended material.

Classification III applies to substances which should be reduced to specified concentrations. Those present in the wastewater profiles utilized for this study are as follows:

Ammonia	0.5 mg/1
Phosphorous	<50 μg/1 in a lake
	<100 μg/1 in a river
pH	6.0-8.5
Chloride	250 mg/1
Nitrates and Nitrites-N	10 mg/1
Coliform	10,000/100 ml

A later issue of design considerations included a revised set of specific effluent quality goals as follows:

BOD_5	<3 mg/1
COD	<5 mg/1
Suspended Solids	<1 mg/1
Phosphorous-P	0.1-0.2 mg/1
Ammonia-N	0.3-0.5 mg/1
Nitrates and Nitrites-N	2.0-2.5 mg/1

All alternatives considered can meet the above criteria with the exception of the limits specified for COD and suspended solids. A more realistic goal for these two constituents is as follows:

COD	<15 mg/l
Suspended Solids	<4 mg/l

The proposed advanced wastewater treatment processes developed for each plant site would be capable of meeting the specified goals (as amended above for COD and suspended solids) at least 90 percent of the time. Upper limits during the remaining 10 percent of the time would not exceed twice the goal.

Cost Estimates

Cost curves were developed by Stanley Consultants specifically for this study for each individual unit process utilized. The cost curves were published under the title "Wastewater Treatment Unit Processes, Estimating Costs 1972" and were furnished to the Detroit District Corps of Engineers as part of Phase I of this study. The cost curves were used for evaluation of alternatives and to develop cost estimates for each wastewater treatment plant.

All construction cost estimates are based on a Detroit Water Quality Office construction cost index of 180.73 for January, 1972. For comparative purposes and to develop annual costs, construction estimates have been amortized over a period of 50 years at an interest rate of 5 1/2 percent. For unit processes which have a useful life of less than 50 years, an amortized replacement cost has been calculated based on replacing units at 1972 costs. This cost has been spread over the 50-year life of the project at the 5 1/2 percent interest rate.

Operation and maintenance cost estimates are based on a labor cost of six dollars per hour, and on power, fuel, replacement parts, and chemicals at January, 1972, price levels. The estimated cost should be sufficient to operate and maintain the equipment for its useful life.

SECTION III - WASTEWATER TREATMENT SYSTEM SELECTION

Alternative Wastewater Treatment Processes

For some elements in the wastewater treatment process (such as pumping and primary clarification), technology is sufficiently well established that only a single approach has been evaluated in detail. For the more complex advanced waste treatment and sludge handling systems, several unit processes have been evaluated at each location on the basis of ability to meet effluent criteria, reliability, impact on the environment, cost effectiveness, and significant intangible and sociological factors.

All alternatives were submitted to the Detroit District in preliminary form for review and selection of the final system processes.

Following is a summary discussion of the factors considered in the situations where a number of technically feasible treatment alternatives exist. The favored treatment approach is outlined in the text which follows and subsequent discussions present the entire recommended system for each plant location, along with detailed assessments of the costs and other significant evaluation parameters.

Ammonia Removal - Four methods were considered for removal of ammonia from the municipal and industrial wastewater: ammonia stripping, selective ion exchange, breakpoint chlorination, and biological nitrification-denitrification. Ammonia can be released to the atmosphere from a stripping tower following adjustment of the pH of the wastewater to approximately 11.5. This approach is not practicable for the study region, however, because the chemical reactions involved are temperature dependent and winter weather in southeast Michigan is too severe for economical year-around operation.

Breakpoint chlorination and selective ion exchange have both been eliminated for economic reasons. In breakpoint chlorination, a high dosage of chlorine (10 pounds per pound of ammonia) is required for ammonia removal. Cost for chlorine becomes prohibitive

considering the high concentrations of ammonia present in the municipal and industrial wastewater. The relatively high cost of clinoptilolite, the exchange media for a selective ion exchange process, causes this alternative to be eliminated from further consideration.

The best process for use in the study area was determined to be biological oxidation of ammonia to nitrate. This is followed by methanol addition, a carbon source for anaerobic bacteria, to convert nitrate and nitrite to nitrogen gas in multi-media filters. The filters will serve the dual purpose of suspended solids reduction, and denitrification.

The same four methods were considered for reduction of ammonia in stormwater flows. Similar negative conclusions were reached with regard to ammonia stripping and selective ion exchange processes. However, biological nitrification-denitrification was considered to be impractical due to the intermittent nature of the waste flow and the slow growth rate of nitrifying organisms. Therefore, breakpoint chlorination was considered the optimum unit process for removal of ammonia from stormwater flows. This approach requires minimal additional equipment since disinfection facilities, designed for the maximum flow rate, must be provided irrespective of the ammonia removal technique employed. Utilization of chlorination equipment for both ammonia removal and disinfection is efficient from a first cost standpoint. Further, ammonia concentrations in stormwater are low enough that chemical costs do not become prohibitive.

Phosphate Removal - Single-stage lime clarification and ferric chloride addition in the primary clarifier were evaluated as alternatives for phosphate removal, but were determined to be inadequate for meeting the desired effluent criteria goals. Two-stage lime clarification was deemed to be the only unit process capable of achieving the high degree of phosphate removal required considering the anticipated low alkalinity of stormwater and municipal-industrial waste.

Heavy Metal Removal - Two methods have been evaluated for removal of heavy metals from both stormwater and municipal-industrial wastewaters. The first alternative involves the ion exchange process, using various selective exchange medias. However, the low concentrations and wide variety of heavy metal ions present make this approach economically unattractive.

The selected heavy metal removal technique results from a combination of two other processes selected for use in the recommended treatment schematic. The high pH-lower pH operation of two-stage lime clarification allows optimum precipitation of most heavy metals. The remaining metals can be removed to the desired levels in the carbon absorption units provided primarily for removal of organic materials.

Primary and Waste Biological Sludge Handling - The final design of specific unit processes for sludge handling and disposal is normally not undertaken without extensive bench and pilot scale investigation at each proposed plant location. Selections between alternatives have, therefore, been tentatively based upon average sludge characteristics and typical design loadings. Sludge handling has been evaluated in five general areas as follows:

1. Thickening (waste biological sludge only).
2. Conditioning (primary and waste biological sludge only).
3. Dewatering.
4. Transportation.
5. Ultimate disposal.

Air flotation and gravity processes have been considered for reducing the water content of waste biological sludge prior to subsequent treatment operations. For the purpose of generating cost developments presented herein, air flotation thickening has been assumed except at plants which have existing gravity thickeners. At Port Huron, an existing gravity unit is used to thicken a mixture of primary and waste biological sludge.

The remaining four categories of sludge handling are interrelated to the extent that a systems analysis must be performed in order to arrive at the final desired arrangement at each location.

Three approaches for conditioning primary and waste biological sludges to produce a material pathologically and aesthetically suitable for ultimate disposal have been reviewed. The three unit processes considered are chemical conditioning, thermal conditioning, and anaerobic digestion. Each of these three alternatives was evaluated as an element in a dewatering, transportation, and ultimate disposal system.

Ultimate disposal of primary and waste biological sludge from a municipal and industrial wastewater treatment plant requires dewatering prior to either landfilling or incineration. Three methods of dewatering, vacuum filtration, centrifugation, and filter pressing, were considered as possible alternatives. Pilot plant investigations could establish the economic and other advantages of each system. Without such studies, cost factors are too sensitive to sludge characteristics to permit differentiation between alternatives. For the purpose of cost estimates presented in this report, vacuum filtration has been assumed at each location except at plants with existing centrifuges.

Present State of Michigan, Department of Public Health guidelines prohibit the burial of wastewater sludge in a sanitary landfill with municipal-industrial refuse unless the sludge contains less than 50 percent moisture, or unless it is thoroughly mixed with refuse to reduce the mixture to this moisture content. However, any sludge cake may be buried under properly controlled conditions in trenches or other excavation used solely for sludge disposal. Measures must be taken to prevent public access and a daily covering of earth or other relatively inert material is required to control odors. A possible alternative is the use of chemicals for odor control in lieu of the daily earth covering. In either case, a final earth cover at least 24 inches deep should be provided followed by seeding or sodding.

Dewatered primary and waste biological sludge is expected to have a solids content of about 25 to 30 percent and cannot be buried in a sanitary landfill with municipal-industrial refuse. Consideration of

mixing sludge and refuse prior to landfilling requires extensive analysis of solid waste volume and composition data which is not readily available. Therefore, for ultimate disposal purposes as outlined in this report, all landfills are considered to be separate and for the burial of wastewater sludge only.

The following alternatives for transportation of primary and waste activated sludge from the municipal and industrial wastewater treatment plants to the landfill sites have been reviewed.

1. Pumping raw (unconditioned) sludge from treatment to disposal site for dewatering and disposal.
2. Trucking raw sludge from treatment to disposal site for dewatering and disposal.
3. Rail transport of raw sludge from treatment to disposal site for dewatering and disposal.
4. Pumping conditioned sludge from treatment to disposal site for dewatering and disposal.
5. Trucking conditioned sludge from treatment to disposal site for dewatering and disposal.
6. Rail transport of conditioned sludge from treatment to disposal site for dewatering and disposal.
7. Trucking dewatered sludge or incinerator ash from treatment to disposal site for disposal.
8. Rail transport of dewatered sludge or incinerator ash from treatment to disposal site for disposal.

When considering landfill disposal the most cost effective transportation method for all treatment plants in the study area consists of trucking either dewatered sludge or incinerator ash.

If surface spreading of stabilized sludge is utilized as the ultimate disposal technique, pumping and pipeline transportation is the most efficient approach.

Two alternatives for ultimate disposal, landfill and surface spreading, were considered to be satisfactory if operated in a proper manner. Table 3 summarizes the estimated costs and land requirements for four complete sludge disposal arrangements considered most feasible:

1. Landfill disposal of dewatered sludge.
2. Landfill disposal of sludge ash following incineration.
3. Surface spreading of anaerobically digested sludge.
4. Surface spreading of thermally conditioned sludge.

Several of the environmental and resource related factors which relate to these sludge handling and disposal systems include the following:

1. A landfill would have to be operated following best possible practices to prevent pollution of groundwater and nuisance to adjacent property owners. Possible future uses of the landfill site would be limited.
2. Surface spreading requires a lagoon for sludge storage during cold months. Relatively large land areas are required for surface disposal of sludge.
3. Surface spreading of digested or thermally conditioned sludge is not anticipated to cause any permanent damage to the land. Air pollution effects should be minimal.
4. Even with the best air pollution control devices, a certain amount of air pollution would result from incineration of sludge. Fuel resources would also have to be expended to maintain adequate combustion temperatures to prevent odor emissions.

TABLE 3

SLUDGE DISPOSAL ALTERNATIVES

Municipal and Industrial Wastewater Treatment Plants	Primary and Waste Biological Sludge - Landfill Disposal					
	Dewatered Sludge Without Incineration			Incinerated Sludge		
	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres
Adrian (12 mgd)	1,241	245	31	1,883	304	2.6
Port Huron (24 mgd)	294	319	53	70	331	9.4
Monroe (40 mgd)	953	492	109	1,152	457	8.4
Wayne County (125 mgd)	1,317	1,107	350	254	1,082	50
Mouth of Huron River (400 mgd)	7,981	2,989	1,100	11,321	3,659	160
Mouth of Huron River (525 mgd)	10,015	3,700	1,440	14,389	4,701	210
Detroit (806 mgd)	6,980	5,283	2,210	6,576	6,125	320

Municipal and Industrial Wastewater Treatment Plants	Primary and Waste Biological Sludge - Surface Spreading					
	Anaerobic Digestion			Thermal Conditioning		
	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres
Adrian (12 mgd)	1,899	279	255	2,273	349	462
Port Huron (24 mgd)	2,616	377	490	2,040	377	675
Monroe (40 mgd)	3,977	534	700	4,311	581	1,000
Wayne County (125 mgd)	11,824	1,389	2,540	13,010	1,559	3,500
Mouth of Huron River (400 mgd)	34,556	3,211	8,150	36,395	3,892	11,200
Mouth of Huron River (525 mgd)	44,894	4,069	10,650	47,227	4,936	14,800
Detroit (806 mgd)	68,950	5,974	16,400	73,240	7,459	22,600

Municipal and Industrial Wastewater Treatment Plants	Chemical Sludge - Landfill Disposal					
	Without Recalcination			With Recalcination		
	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres	Capital Cost(1)	Total Annual Cost(1)	Land Required Acres
Adrian (12 mgd)	439	137	33	685	311	3.3
Port Huron (24 mgd)	632	206	66	934	365	7.0
Monroe (40 mgd)	688	257	104	1,041	523	11.2
Wayne County (125 mgd)	1,458	641	343	1,609	1,153	35
Mouth of Huron River (400 mgd)	4,532	1,469	1,090	4,336	3,010	113
Mouth of Huron River (525 mgd)	5,636	1,874	1,435	5,059	3,816	148
Detroit (806 mgd)	6,706	2,686	2,225	4,923	5,430	227
Stormwater Treatment Plants						
East China (125 mgd)	1,931	507	240	2,482	636	16
Plymouth or Ypsilanti (225 mgd)	3,057	816	433	3,548	971	29
Macomb County (400 mgd)	4,832	1,217	767	5,135	1,417	51
Conner Creek (600 mgd)	5,637	1,618	883	6,082	1,830	67
Monroe County (1,000 mgd)	8,576	2,101	1,470	8,636	2,803	113
Conner Creek (1,200 mgd)	10,394	2,905	1,763	9,907	3,349	136
Monroe County (1,400 mgd)	12,646	3,012	2,272	11,798	3,822	166

(1) Cost is in thousands of dollars per year.

5. Anaerobic digestion presents the most efficient alternative from the standpoint of resource conservation. Anaerobic bacteria reduce the volatile portion of the sludge, producing methane gas which can be used to heat the digesters and provide auxilliary fuel for other uses in the treatment process.
6. Thermal conditioning requires substantial fuel input to maintain adequate temperatures for the process.

The foregoing environmental factors do not appear to be of sufficient magnitude to justify selection of anything but the least cost alternative in each situation. Therefore, the following alternatives were selected for each of the seven municipal and industrial wastewater treatment facilities for handling and disposal of primary and waste biological sludge:

1. Adrian - landfill disposal of dewatered thermally conditioned sludge.
2. Port Huron - landfill disposal of dewatered thermally conditioned sludge.
3. Monroe - landfill disposal of ash following incineration.
4. Wayne County - landfill disposal of ash following incineration.
5. Mouth of the Huron (400 mgd) - landfill disposal of dewatered sludge.
6. Mouth of the Huron (525 mgd) - landfill disposal of dewatered sludge.
7. Detroit - landfill disposal of dewatered sludge.

Chemical Sludge Disposal - Evaluation of alternatives for disposal of chemical sludge generated by the two-stage lime clarification treatment of both municipal-industrial wastewaters and stormwater involves many of the same factors previously outlined for disposal of primary and biological sludge. The major additional factor to be included in the comparison involves the possible recalcination and reuse of lime sludge. Recalcination cannot be justified entirely on a cost basis. Lime recovery is estimated

at less than 20 percent due to the low wastewater alkalinity. Recalcination of sludge creates a possible source of air pollution and requires consumption of fuel resources. This factor is offset by the air pollution and fuel requirements necessary for calcination of limestone to produce new lime for the treatment process if recalcination is not practiced.

Two approaches, landfill and surface spreading, were considered for ultimate disposal of chemical sludge. The latter choice was eliminated from consideration due to the large land area required to permit a satisfactory loading rate of 3 tons of dry solids per acre per year. Therefore, subsequent analyses are based upon landfill disposal of chemical sludge.

Landfill disposal must be provided either for waste recalcination ash or dewatered chemical sludge. Dewatering could be accomplished by vacuum filtration, centrifugation, or filter pressing. Before final selection is undertaken, a pilot scale investigation would be desirable at each location. For the purposes of present cost comparisons, vacuum filtration has been assumed at each location except those plants with existing centrifuges. Dewatered lime sludge is expected to have a solids content of about 40 to 50 percent.

Table 3 presents relative costs and land requirements for comparison of landfilling of dewatered chemical sludge and waste recalcination ash. As shown, the total annual cost for disposal without recalcination is significantly less than for the recalcination alternative. Land requirements, however, are substantially less for disposal of excess recalcination ash. Based upon evaluation of the foregoing information, by the Detroit District, the recalcination alternative has been selected for inclusion in the final wastewater treatment arrangements.

All stormwater treatment plants except the 125 mgd facility located in East China Township will be provided with recalcination facilities. Similarly, all municipal-industrial wastewater treatment plants except the small facilities located at Adrian, Port Huron, and Monroe will utilize chemical sludge recalcination. Dewatering and landfill disposal will be provided for the four

facilities without recalcination. Landfill sites will also be required in conjunction with all recalcination plants. Transportation of either recalcination ash or dewatered chemical sludge will be by truck.

Recommended Municipal and Industrial Wastewater Treatment Systems

The wastewater flow arrangements for the seven municipal and industrial wastewater treatment plants are similar except for the sludge handling and disposal systems. Schematic diagrams of the plants are presented in Figures 6 through 12. Cost estimates for the recommended facilities are summarized in Tables 4 through 10.

Treatment of the liquid portion of the wastewater consists of the following unit processes:

1. Raw waste pumping. Pumping stations are provided at each treatment plant to provide sufficient head for the wastewater to flow through the subsequent units by gravity.
2. Preliminary treatment including screening, grit removal, and metering. Screening is provided to remove large floating objects and debris which might damage or obstruct subsequent unit processes. Grit removal protects mechanical equipment from abrasive particles of sand, gravel, and similar materials.
3. Primary clarification. Conventional primary treatment and sludge pumping equipment facilitates the separation and removal of settleable solids from the wastewater stream.
4. Aeration and secondary clarification. Proposed biological treatment for the municipal-industrial wastewater utilizes an activated sludge process with either conventional aeration equipment or pure oxygen. Pilot plant investigations would be necessary before a detailed economic comparison could be made between the two systems. For the purpose of establishing the costs presented in this report, a complete-mix activated sludge diffused air system has been used except at locations where pure oxygen facilities are presently in use. Final clarification and return sludge pumping have

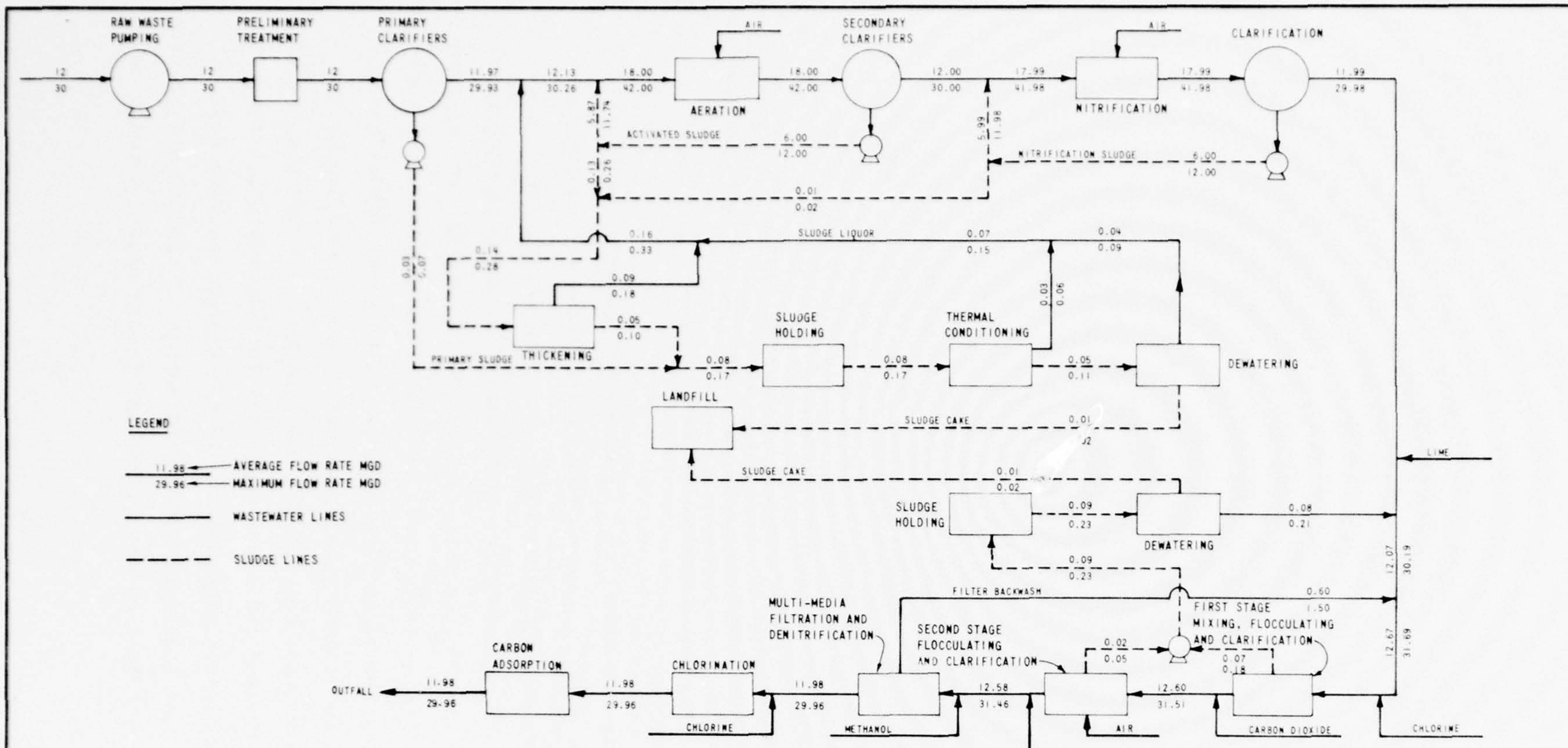


FIGURE 6

PROPOSED ADRIAN 12 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 4

COST ESTIMATE
FOR
12 MGD ADRIAN WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	0.81	48	--	18	66
Preliminary Treatment	0.18	11	--	25	36
Primary Clarifiers	0.39	23	--	21	44
Intermediate Pumping	--	--	--	--	--
Aeration Tanks	0.57	34	--	--	34
Diffused Air System	0.51	30	8	91	129
Secondary Clarifiers	0.59	35	--	25	60
Nitification Tanks	0.63	37	--	--	37
Diffused Air System	0.64	38	10	114	162
Clarifiers	0.59	35	--	25	60
Two-Stage Lime Clarification	1.20	71	--	198	269
Multi-Media Filtration Denitrification	1.80	106	--	206	312
Granular Carbon Adsorption	2.05	121	3	190	314
Chlorine Contact Tanks	--	--	--	--	--
Chlorination Feed System	0.37	22	--	20	42
Sludge Holding	0.10	6	--	9	15
Sludge Thickening	0.08	5	1	4	10
Thermal Conditioning	0.69	41	11	37	89
Dewatering	0.39	23	6	64	93
Recalcination	--	--	--	--	--
Incineration	--	--	--	--	--
Hauling	0.03	2	2	33	37
Landfill	0.31	18	4	99	121
Instrumentation	0.23	14	--	12	26
Land Required (27 acres)	0.04	2	--	--	2
Site Work and Piping	0.81	48	--	31	79
Garage and Shop	0.06	4	--	--	4
Administration and Laboratory Facilities	0.17	10	--	61	71
Outfall	0.06	4	--	--	4
Total Construction Cost	13.30	788	45	1,283	2,116
Engineering, Legal, Administration, and Contingencies	3.99	236	--	--	236
Total Project Cost	17.29	1,024	45	1,283	2,352

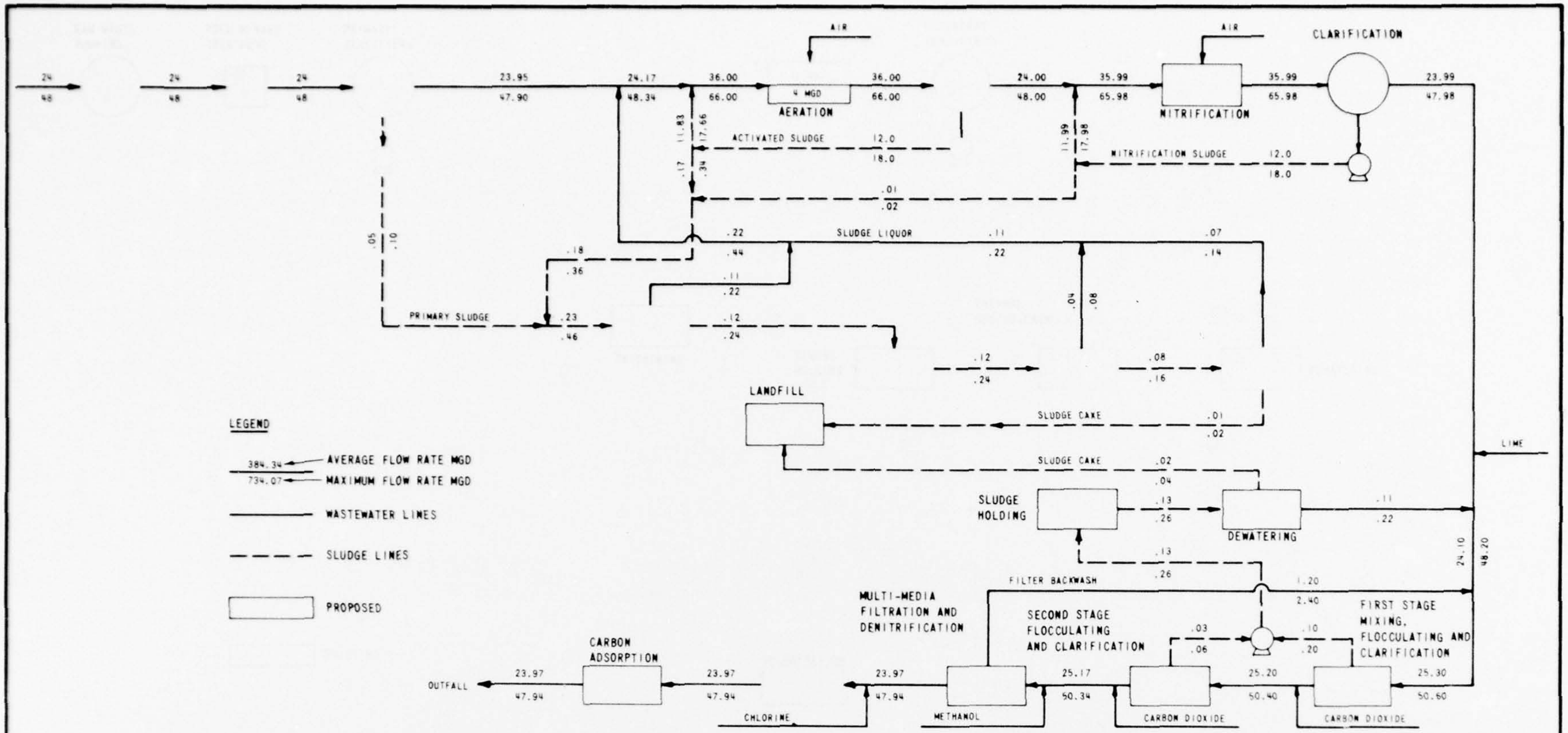


FIGURE 7

PROPOSED PORT HURON 24 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 5

COST ESTIMATE
FOR
24 MGD PORT HURON WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	--	--	--	29	29
Preliminary Treatment	--	--	--	41	41
Primary Clarifiers	--	--	--	30	30
Intermediate Pumping	--	--	--	--	--
Aeration Tanks	0.26	15	--	--	15
Diffused Air System	0.16	9	9	104	122
Secondary Clarifiers	--	--	--	39	39
Nitrification Tanks	1.10	65	--	--	65
Diffused Air System	0.71	42	11	125	178
Clarifiers	1.02	60	--	39	99
Two-Stage Lime Clarification	1.95	115	--	364	479
Multi-Media Filtration Denitrification	2.42	143	--	359	502
Granular Carbon Adsorption	3.45	204	5	298	507
Chlroine Contact Tanks	--	--	--	--	--
Chlorination Feed System	0.40	24	--	31	55
Sludge Holding	0.07	4	--	24	28
Sludge Thickening	--	--	--	6	6
Thermal Conditioning	--	--	13	49	62
Dewatering	0.22	13	11	119	143
Recalcination	--	--	--	--	--
Incineration	--	--	--	--	--
Hauling	0.07	4	5	61	70
Landfill	0.48	28	6	143	177
Instrumentation	0.18	11	--	9	20
Land Required (38 acres)	*	*	--	--	*
Site Work and Piping	0.71	42	--	54	96
Garage and Shop	0.05	3	--	--	3
Administration and Laboratory Facilities	0.09	5	--	88	93
Outfall	--	--	--	--	--
Total Construction Cost	13.34	787	60	2,012	2,859
Engineering, Legal, Administration, and Contingencies	4.00	236	--	--	236
Total Project Cost	17.34	1,023	60	2,012	3,095

* Cost of additional land is not available.

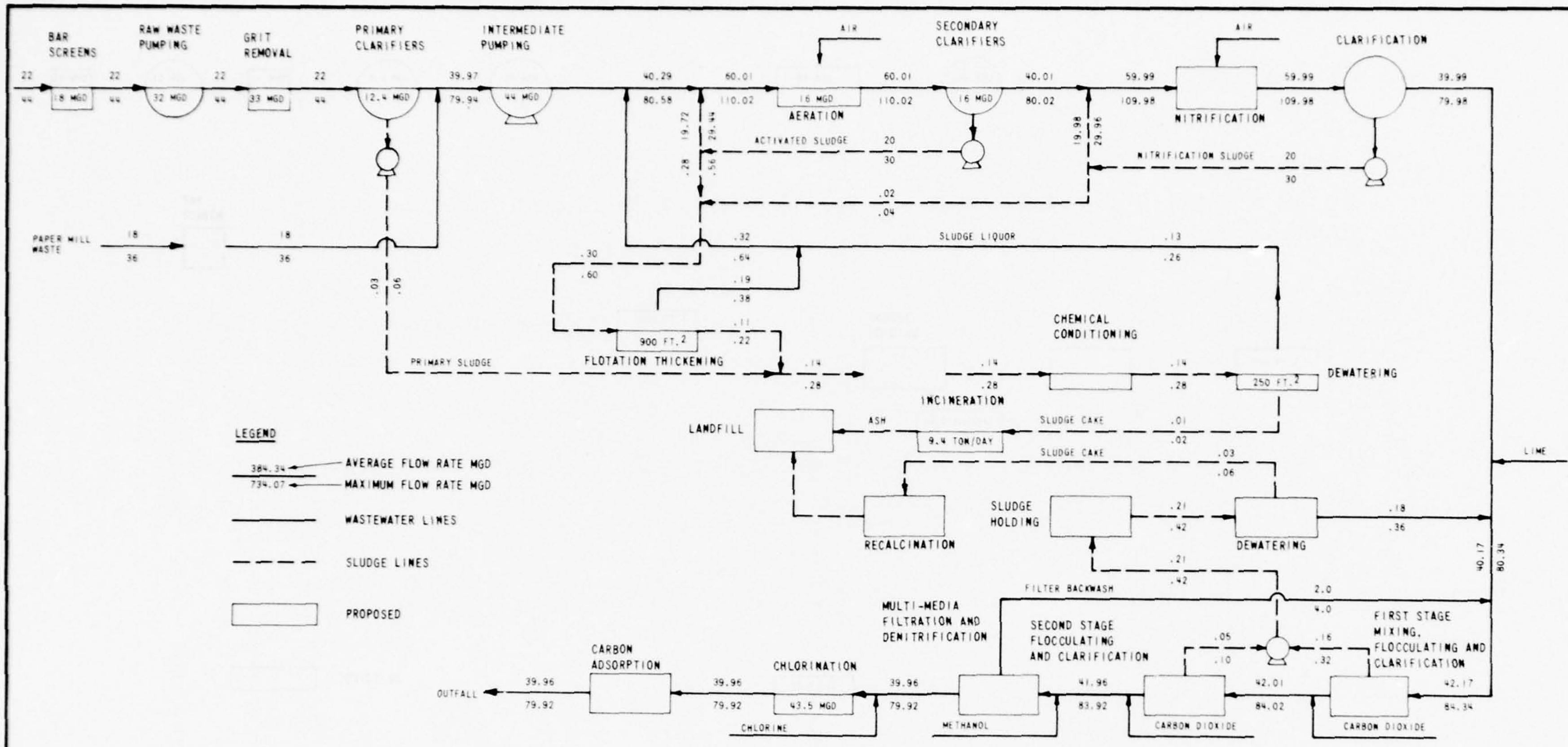


FIGURE 8

PROPOSED MONROE 40 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 6

COST ESTIMATE
FOR
40 MGD MONROE WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	0.85	50	--	45	95
Preliminary Treatment	0.18	11	--	63	74
Primary Clarifiers	0.41	24	--	40	64
Intermediate Pumping	1.10	65	--	39	104
Aeration Tanks	0.71	42	--	--	42
Diffused Air System	0.52	31	17	194	242
Secondary Clarifiers	0.73	43	--	57	100
Nitrification Tanks	1.67	99	--	--	99
Diffused Air System	1.13	67	18	205	290
Clarifiers	1.58	93	--	57	150
Two-Stage Lime Clarification	2.88	170	--	569	739
Multi-Media Filtration Denitrification	3.50	207	--	548	755
Granular Carbon Adsorption	5.30	313	8	431	752
Chlorine Contact Tanks	0.10	6	--	--	6
Chlorination Feed System	0.57	34	--	43	77
Sludge Holding	--	--	--	24	24
Sludge Thickening	0.09	5	2	11	18
Thermal Conditioning	--	--	--	--	--
Dewatering	0.52	31	13	204	248
Recalcination	--	--	--	--	--
Incineration	0.70	41	19	131	191
Hauling	0.05	3	4	41	48
Landfill	0.45	27	5	136	168
Instrumentation	0.23	14	--	17	31
Land Required (50 acres)	*	*	--	--	*
Site Work and Piping	1.13	67	--	82	149
Garage and Shop	0.07	4	--	--	4
Administration and Laboratory Facilities	0.11	6	--	120	126
Outfall	--	--	--	--	--
Total Construction Cost	24.58	1,453	86	3,057	4,596
Engineering, Legal, Administration, and Contingencies	7.37	435	--	--	435
Total Project Cost	31.95	1,888	86	3,057	5,031

* Cost of additional land is not available.

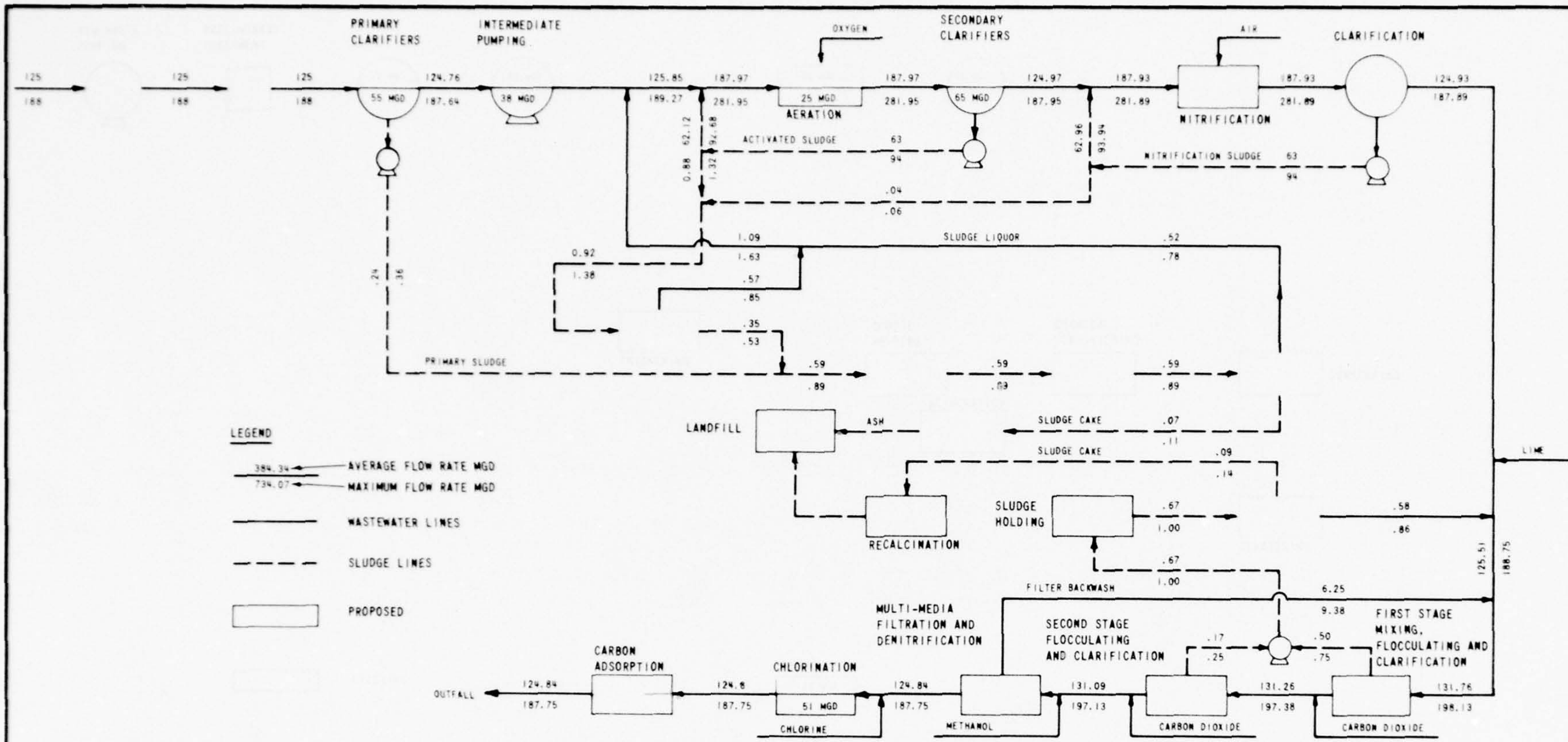


FIGURE 9

PROPOSED WAYNE COUNTY 125 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 7

COST ESTIMATE
FOR
125 MGD WAYNE COUNTY WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	--	--	--	135	135
Preliminary Treatment	--	--	--	164	164
Primary Clarifiers	1.4	83	--	79	162
Intermediate Pumping	1.0	59	--	119	178
Aeration Tanks	0.5	30	--	--	30
Diffused Air System	0.7	41	40	526	607
Secondary Clarifiers	2.4	142	--	144	286
Nitrification Tanks	4.6	272	--	--	272
Diffused Air System	2.2	130	34	412	576
Clarifiers	4.4	260	--	144	404
Two-Stage Lime Clarification	8.0	473	--	1,643	2,116
Multi-Media Filtration Denitrification	7.0	413	--	1,483	1,896
Granular Carbon Adsorption	14.0	827	22	1,049	1,898
Chlorine Contact Tanks	0.1	6	--	--	6
Chlorination Feed System	0.9	53	--	98	151
Sludge Holding	0.2	11	--	34	45
Sludge Thickening	--	--	5	43	48
Thermal Conditioning	--	--	--	--	--
Dewatering	--	--	26	559	585
Recalcination	1.3	77	20	818	915
Incineration	--	--	--	393	393
Hauling	0.1	6	7	78	91
Landfill	0.4	24	5	104	133
Instrumentation	0.5	30	--	25	55
Land Required (100 acres)	*	*	--	--	*
Site Work and Piping	2.4	142	--	201	343
Garage and Shop	0.1	6	--	--	6
Administration and Laboratory Facilities	0.2	12	--	228	240
Outfall	--	--	--	--	--
Total Construction Cost	52.4	3,097	159	8,479	11,735
Engineering, Legal, Administration and Contingencies	15.7	927	--	--	927
Total Project Cost	68.1	4,024	159	8,479	12,662

* Cost of additional land is not available.

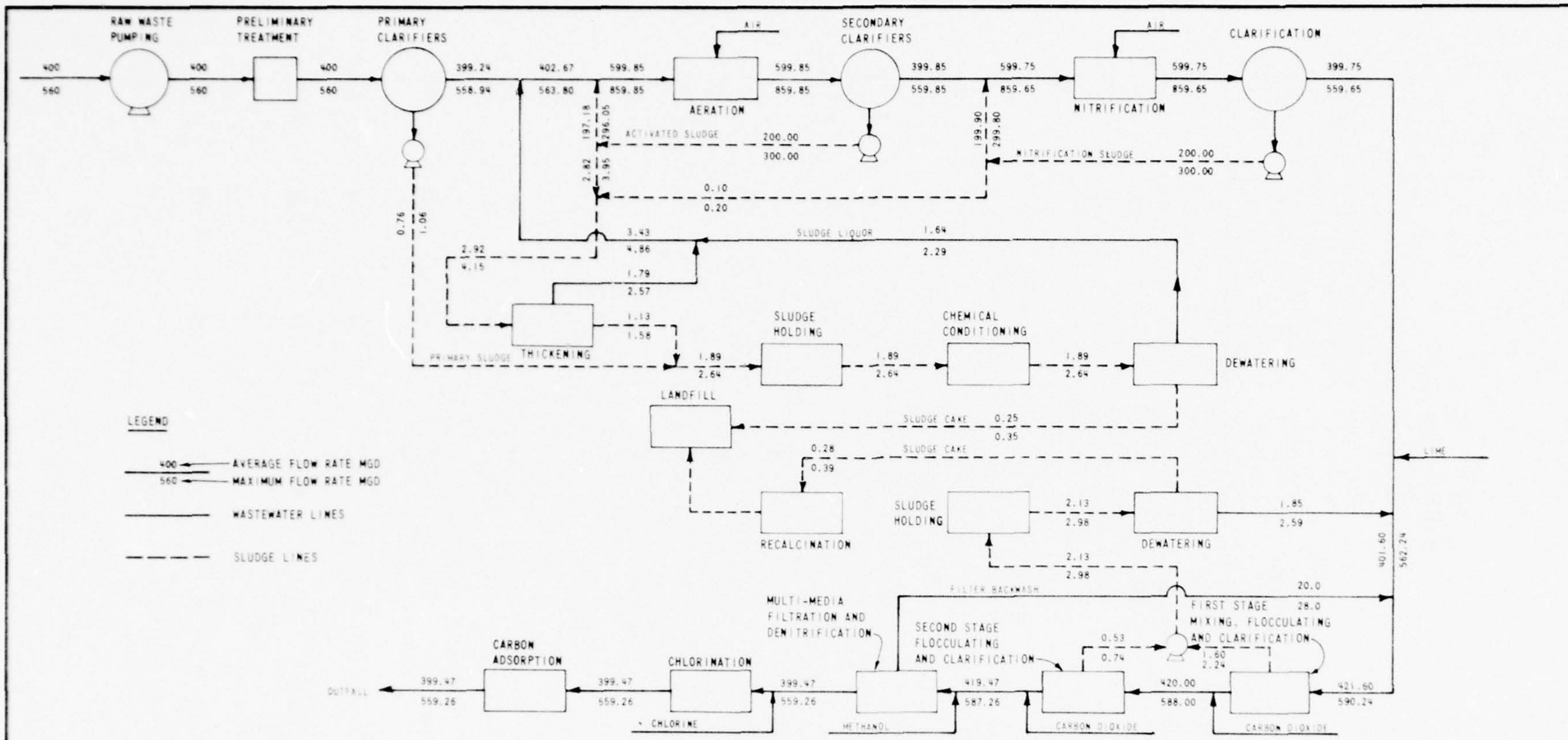


FIGURE 10

PROPOSED MOUTH OF HURON RIVER 400 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 8

COST ESTIMATE
FOR
400 MGD MOUTH OF HURON RIVER WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	8.8	520	--	409	929
Preliminary Treatment	1.4	83	--	445	528
Primary Clarifiers	8.6	508	--	177	685
Intermediate Pumping	--	--	--	--	--
Aeration Tanks	11.5	679	--	--	679
Diffused Air System	5.3	313	82	1,113	1,508
Secondary Clarifiers	12.8	756	--	390	1,146
Nitrification Tanks	13.7	809	--	--	809
Diffused Air System	5.3	313	82	1,124	1,519
Clarifiers	12.8	756	--	390	1,146
Two-Stage Lime Clarification	22.5	1,329	--	4,920	6,249
Multi-Media Filtration Denitrification	20.5	1,211	--	4,278	5,489
Granular Carbon Adsorption	39.0	2,303	60	2,803	5,166
Chlorine Contact Tanks	0.9	53	--	--	53
Chlorination Feed System	2.0	118	--	246	364
Sludge Holding	0.8	47	--	55	102
Sludge Thickening	0.6	35	9	21	65
Thermal Conditioning	--	--	--	--	--
Dewatering	4.7	278	73	1,552	1,903
Recalcination	2.4	142	37	2,190	2,369
Incineration	--	--	--	--	--
Hauling	0.3	18	22	369	409
Landfill	3.4	201	38	722	961
Instrumentation	1.4	83	--	70	153
Land Required (205 acres)	0.3	18	--	--	18
Site Work and Piping	6.1	360	--	511	871
Garage and Shop	0.7	41	--	--	41
Administration and Laboratory Facilities	1.3	77	--	438	515
Outfall	0.4	24	--	--	24
Total Construction Cost	187.5	11,075	403	22,223	33,701
Engineering, Legal, Administration, and Contingencies	56.3	3,325	--	--	3,325
Total Project Cost	243.8	14,400	403	22,223	37,026

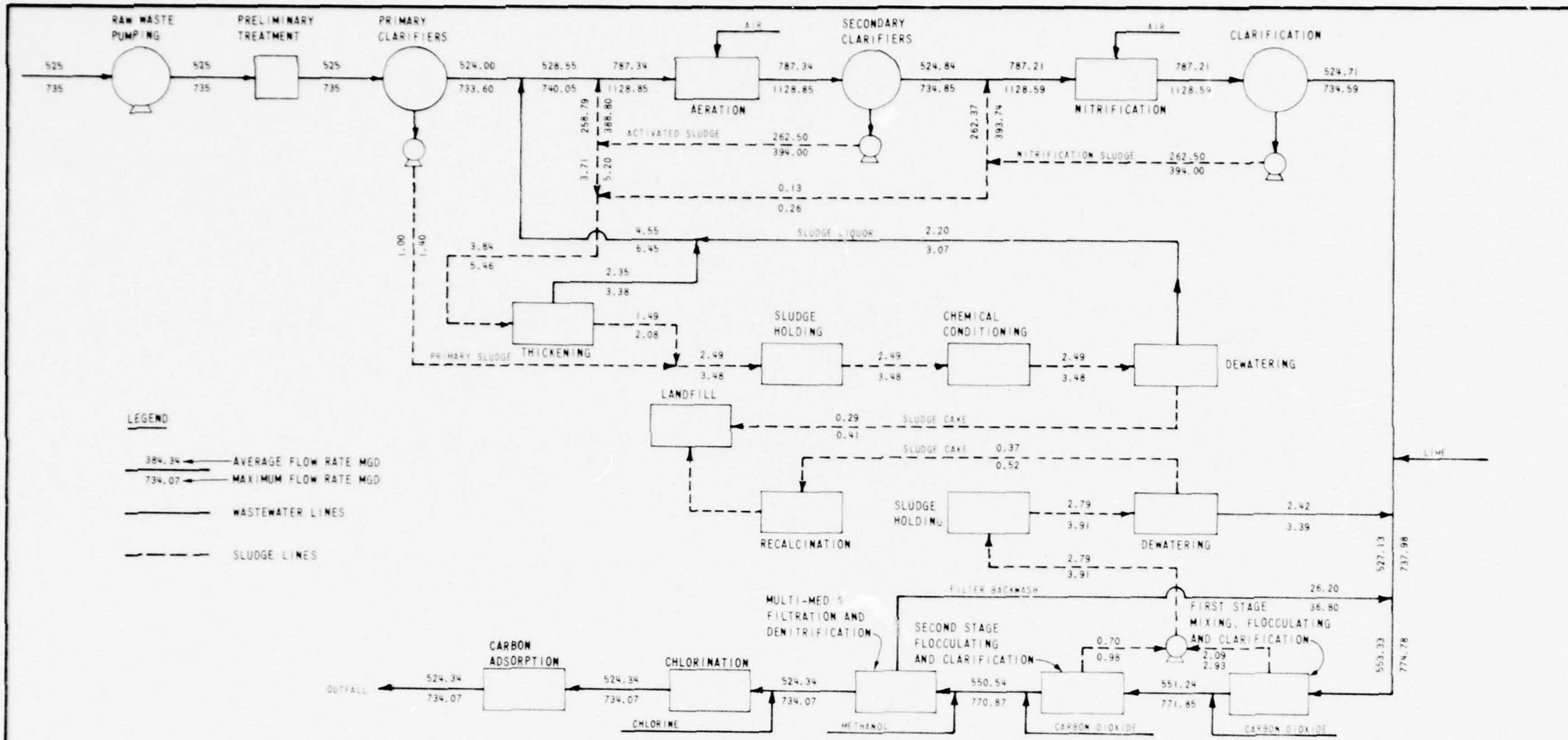


FIGURE 11

PROPOSED MOUTH OF HURON RIVER 525 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 9

COST ESTIMATE
FOR
525 MGD MOUTH OF HURON RIVER WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	10.8	638	--	527	1,165
Preliminary Treatment	1.7	100	--	565	665
Primary Clarifiers	11.1	656	--	218	874
Intermediate Pumping	--	--	--	--	--
Aeration Tanks	15.0	886	--	--	886
Diffused Air System	6.6	390	102	1,441	1,933
Secondary Clarifiers	16.7	986	--	498	1,484
Nitrification Tanks	17.6	1,039	--	--	1,039
Diffused Air System	6.6	390	102	1,438	1,930
Clarifiers	16.7	986	--	498	1,484
Two-Stage Lime Clarification	29.0	1,713	--	6,381	8,094
Multi-Media Filtration Denitrification	27.0	1,595	--	5,519	7,114
Granular Carbon Adsorption	51.0	3,012	79	3,603	6,694
Chlorine Contact Tanks	1.1	65	--	--	65
Chlorination Feed System	2.5	148	--	308	456
Sludge Holding	0.9	53	--	68	121
Sludge Thickening	0.8	47	12	28	87
Thermal Conditioning	--	--	--	--	--
Dewatering	5.9	348	91	2,008	2,447
Recalcination	2.7	159	42	2,930	3,131
Incineration	--	--	--	--	--
Hauling	0.4	24	29	485	538
Landfill	4.1	242	46	797	1,085
Instrumentation	1.8	106	--	90	196
Land Required (245 acres)	0.3	20	--	--	20
Site Work and Piping	7.9	467	--	632	1,099
Garage and Shop	0.8	47	--	--	47
Administration and Laboratory Facilities	1.6	95	--	517	612
Outfall	0.4	24	--	--	24
Total Construction Cost	241.0	14,236	503	28,551	43,290
Engineering, Legal, Administration, and Contingencies	72.3	4,270	--	--	4,270
Total Project Cost	313.3	18,506	503	28,551	47,560

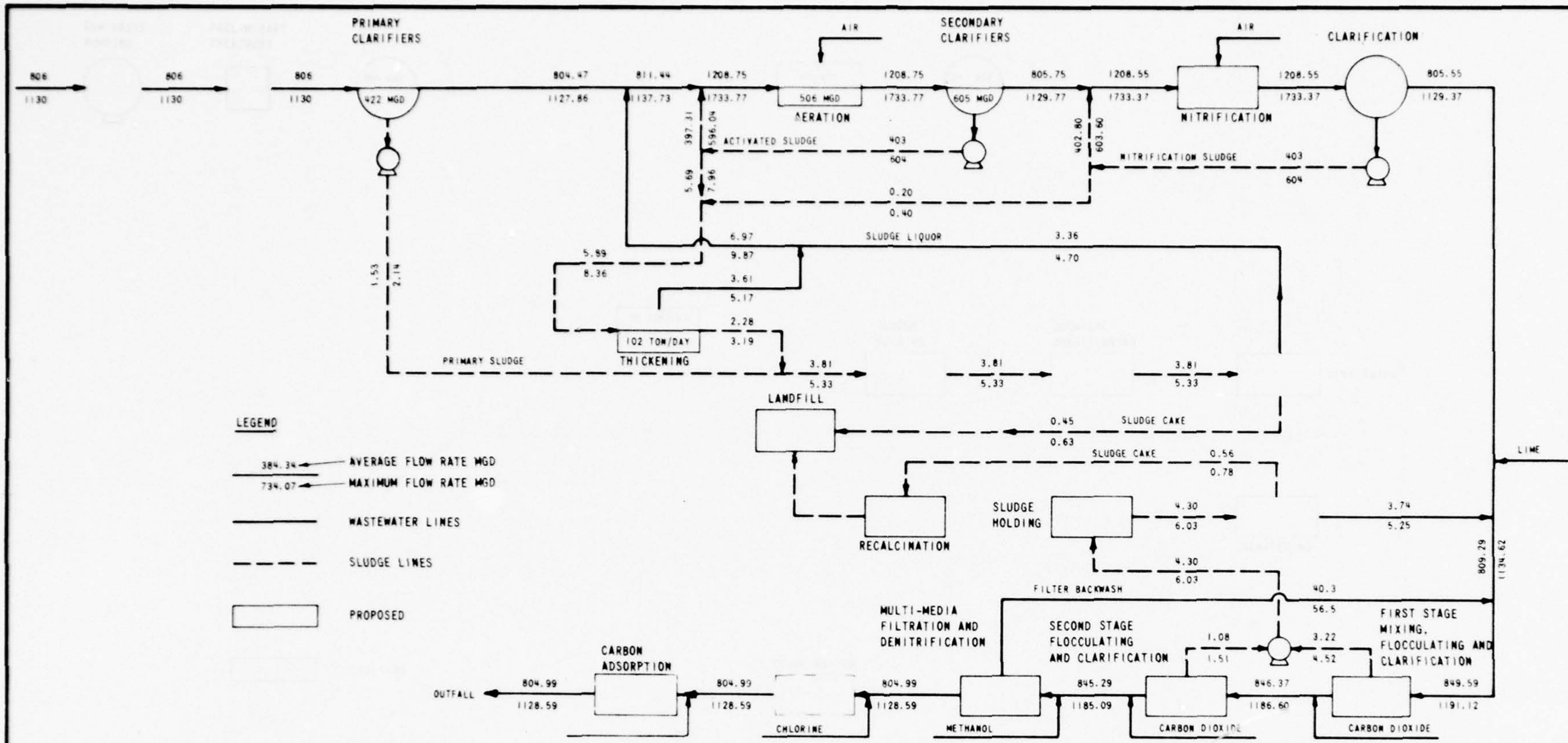


FIGURE 12

PROPOSED DETROIT 806 MGD ADVANCED WASTEWATER TREATMENT PLANT

TABLE 10

COST ESTIMATE
FOR
806 MGD DETROIT WASTEWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year	Total Treatment Cost Thousands of Dollars Per Year
Raw Waste Pumping	--	--	--	794	794
Preliminary Treatment	--	--	--	818	818
Primary Clarifiers	9.0	532	--	318	850
Intermediate Pumping	--	--	--	--	--
Aeration Tanks	14.5	856	--	--	856
Diffused Air System	6.4	378	142	2,124	2,644
Secondary Clarifiers	19.0	1,122	--	730	1,852
Nitrification Tanks	27.0	1,595	--	--	1,595
Diffused Air System	9.3	549	144	2,156	2,849
Clarifiers	25.0	1,477	--	730	2,207
Two-Stage Lime Clarification	43.0	2,540	--	9,620	12,160
Multi-Media Filtration Denitrification	42.0	2,481	--	8,178	10,659
Granular Carbon Adsorption	75.0	4,430	116	5,295	9,841
Chlorine Contact Tanks	--	--	--	--	--
Chlorination Feed System	3.5	207	--	450	657
Sludge Holding	0.7	41	--	89	130
Sludge Thickening	0.6	35	17	42	94
Thermal Conditioning	--	--	--	--	--
Dewatering	--	--	138	2,940	3,078
Recalcination	3.4	201	53	4,350	4,604
Incineration	--	--	--	--	--
Hauling	0.5	30	36	925	991
Landfill	6.5	384	72	1,218	1,674
Instrumentation	2.0	118	--	100	218
Land Required (320 acres)	*	*	--	--	*
Site Work and Piping	9.9	585	--	897	1,482
Garage and Shop	0.6	35	--	--	35
Administration and Laboratory Facilities	0.7	41	--	647	688
Outfall	--	--	--	--	--
Total Construction Cost	298.6	17,637	718	42,421	60,776
Engineering, Legal, Administration, and Contingencies	89.6	5,292	--	--	5,292
Total Project Cost	388.2	22,929	718	42,421	66,068

* Cost of additional land is not available.

been included for recirculation and removal of the bio-mass in the activated sludge system. Approximately 90 percent removal of BOD and suspended solids is anticipated in this process step.

5. Nitrification and clarification. This biological treatment step is similar in operation to a conventional activated sludge process. The system is designed, however, to create a bio-mass of nitrifying bacteria to convert ammonia nitrogen to the nitrate and nitrite forms. Nitrification also further reduces the levels of BOD and COD.
6. Two-stage lime clarification. Chemical clarification is recommended for phosphorus and heavy metal removal. A two-stage process is necessary for achieving a high degree of phosphorus removal with wastewaters low in bicarbonate alkalinity. In addition, the high pH-lower pH first and second stages were planned for optimum precipitation of heavy metals. Recarbonation follows both stages to reduce the pH to an acceptable level.
7. Multi-media filtration and denitrification. The polishing filtration stage is provided to remove about 90 percent of the suspended solids carryover from the chemical clarifiers. Nitrates formed during the nitrification step are converted to nitrogen gas by denitrifying bacteria, if an additional carbon source is provided. Laboratory and pilot plant studies have shown that nitrate removals greater than 90 percent can be accomplished in packed reactors. Nitrate removal in multi-media filters will require the addition of methanol as a carbon source and will result in the need for more frequent backwashing than if the filters were used only for removal of suspended solids.
8. Chlorination. The treated municipal and industrial wastewater will normally be chlorinated for disinfection purposes only. This step will reduce the coliform count to a level below 1,000 per 100 ml. Breakpoint chlorination capability will be provided as a backup system to remove ammonia nitrogen if the biological nitrification process is upset or temporarily out of service.

9. Activated carbon adsorption. Granular activated carbon will adsorb a large percentage of the refractory organic material remaining after filtration. This includes tanins, lignins, proteinaceous substances, pesticides, and similar trace materials. A carbon contact time of about 15 minutes will remove 50 to 60 percent of the remaining organics and result in a final effluent BOD_5 and COD of 1 and 10 mg/l, respectively. Further reductions could be obtained with longer contact times or a second carbon adsorption step. It is anticipated that carbon adsorption will also assist in further reducing the concentrations of heavy metals in the effluent and in removing toxic chloramines resulting from temporary utilization of the breakpoint chlorination process.

Following is a brief discussion of each of the seven municipal-industrial wastewater treatment plants which outlines features unique to each particular location. The specific facilities compliment the unit processes common to all plants as presented in the previous general discussion.

Adrian (12 mgd) - The flow schematic for the proposed Adrian wastewater treatment plant is presented in Figure 6. This will be a completely new facility.

Adrian is the only plant with cyanide in the raw wastewater profile. Therefore, a unique feature of the Adrian facility is the use of alkaline chlorination for cyanide removal. This process involves addition of chlorine ahead of the lime clarification process to oxidize the cyanide ion to carbon dioxide and nitrogen gas.

The proposed sludge handling sequence for the Adrian plant consists of flotation thickening of waste biological sludge prior to mixing with primary sludge. The mixed sludges will be thermally conditioned and dewatered on vacuum filters. Sludge cake from the vacuum filters will be hauled to landfill for disposal with liquor from the thickening, thermal conditioning, and dewatering processes, returned to the wastewater flow ahead of the aeration tanks. Chemical sludge from the lime clarification process will be dewatered on vacuum filters with the sludge cake hauled to landfill disposal. Filtrate from the vacuum filter process, and multi-media filter

backwash water will be returned to the flow stream entering the first-stage chemical clarifier. Sludge holding facilities with mixing equipment will be provided for both the mixed primary and waste biological sludge, and the chemical sludge from the lime clarification process.

Port Huron (24 mgd) - The proposed Port Huron wastewater treatment plant is designed to take maximum advantage of existing facilities. The flow schematic for the proposed plant is shown in Figure 7. Existing raw water pumping, preliminary treatment, primary clarification, and secondary clarification facilities are of adequate design and sufficient capacity to be incorporated in the proposed expanded treatment facility. The existing activated sludge and chlorination unit processes will be used and expanded to meet the system design capacity. The remaining processes (nitrification, chemical clarification, multi-media filtration, denitrification, and carbon adsorption) are proposed as completely new installations.

Primary and waste activated sludge will be mixed prior to thickening in an existing gravity thickener. The thickened sludge will be thermally conditioned in existing units and dewatered with existing centrifuges. The dewatered sludge will be hauled to a landfill for disposal. Lime sludge from the two-stage lime clarification process will be dewatered on new vacuum filters with sludge cake hauled to landfill for disposal. Sludge holding facilities for the primary and waste biological sludge are four old anaerobic digesters converted to holding tanks. New sludge holding tanks are necessary for the chemical sludge.

Monroe (40 mgd) - A flow schematic for the proposed Monroe wastewater treatment plant is presented in Figure 8. As indicated, extensive use has been made of existing facilities although additional capacity is required in the following processes.

1. Raw waste pumping.
2. Screening and grit removal.

3. Primary clarification.
4. Aeration and secondary clarification.
5. Incineration.
6. Chlorination.

The Monroe plant is presently designed to provide primary treatment for 22 mgd of municipal-industrial wastewater. Existing units following primary clarification are designed to handle an additional 18 mgd of paper mill wastewater. An intermediate pumping lift is provided ahead of the aeration phase.

Existing air flotation units will be supplemented with additional capacity to dewater the expected increased quantities of waste biological sludge. Primary sludge will be mixed with thickened waste biological sludge before chemical conditioning and dewatering on vacuum filters. A lower than average vacuum filtration rate of 3.5 pounds per hour per square foot has been utilized in this plant because paper mill sludge is difficult to dewater. Additional capacity will be necessary to supplement the existing vacuum filters.

Filter cake will be incinerated and the ash hauled to landfill for disposal. Existing incinerator capacity will be expanded to handle an additional 9.4 tons per day of dry solids. Lime sludge from the chemical clarification process will be dewatered on vacuum filters with the filter cake hauled to a landfill for disposal.

All of the advanced waste treatment units in the flow schematic have been designed as entirely new units.

Wayne County (125 mgd) - The Wayne County wastewater treatment plant also takes maximum advantage of existing treatment facilities. A flow schematic of the proposed facility is presented in Figure 9. The raw waste pumping and preliminary treatment units at the existing plant have sufficient capacity to meet the specified design flow rate. Primary clarification and intermediate pumping require expansion of capacity. A pure oxygen activated sludge process is presently utilized; however, sufficient capacity is not provided to meet the 125 mgd design value. A pure oxygen system addition

is proposed for secondary treatment of an additional 25 mgd. Construction of additional capacity is also required for secondary clarification and chlorination facilities. The remainder of the wastewater treatment processes are designed as new units.

Sludge facilities at the existing plant are adequate for expected volumes of both primary and waste biological sludge. These facilities include thickening, sludge holding, chemical conditioning, vacuum filtration, and incineration. Lime sludge from the clarification process will be dewatered on existing vacuum filters prior to recalcination. Recalcination furnaces heat the calcium sludge, driving off the water and carbon dioxide leaving only calcium oxide (quick lime). A portion of the calcium oxide will be wasted to prevent a buildup of impurities. The waste ash from the recalcination furnaces will be hauled to a landfill for disposal.

Mouth of Huron River (400 mgd and 525 mgd) - Two plant designs have been developed for the site at the Mouth of the Huron River. Both are designed as completely new facilities and both utilize the same wastewater treatment unit processes. Flow schematics for the two plants are presented in Figures 10 and 11.

The same general arrangement for treatment of the liquid wastes as previously outlined will be utilized. Sludge treatment facilities consist of flotation thickening of waste biological sludge which is then mixed with primary sludge. The mixed sludge is chemically conditioned and dewatered on vacuum filters with the resulting filter cake hauled to a landfill for disposal. Lime sludge from the chemical clarification process will be dewatered on vacuum filters and the sludge cake will be recalcined to recover lime. Waste recalcination ash will be hauled to a landfill.

Detroit (806 mgd) - The flow schematic for the proposed Detroit wastewater treatment facility is presented in Figure 12. Raw waste pumping and preliminary treatment facilities at the existing Detroit plant are of sufficient capacity to handle the specified flow volume. Existing primary clarification, aeration,

secondary clarification, and chlorination unit processes will be utilized in the proposed facility, but will require expansion of present capacity. The remaining wastewater treatment processes are designed as new units.

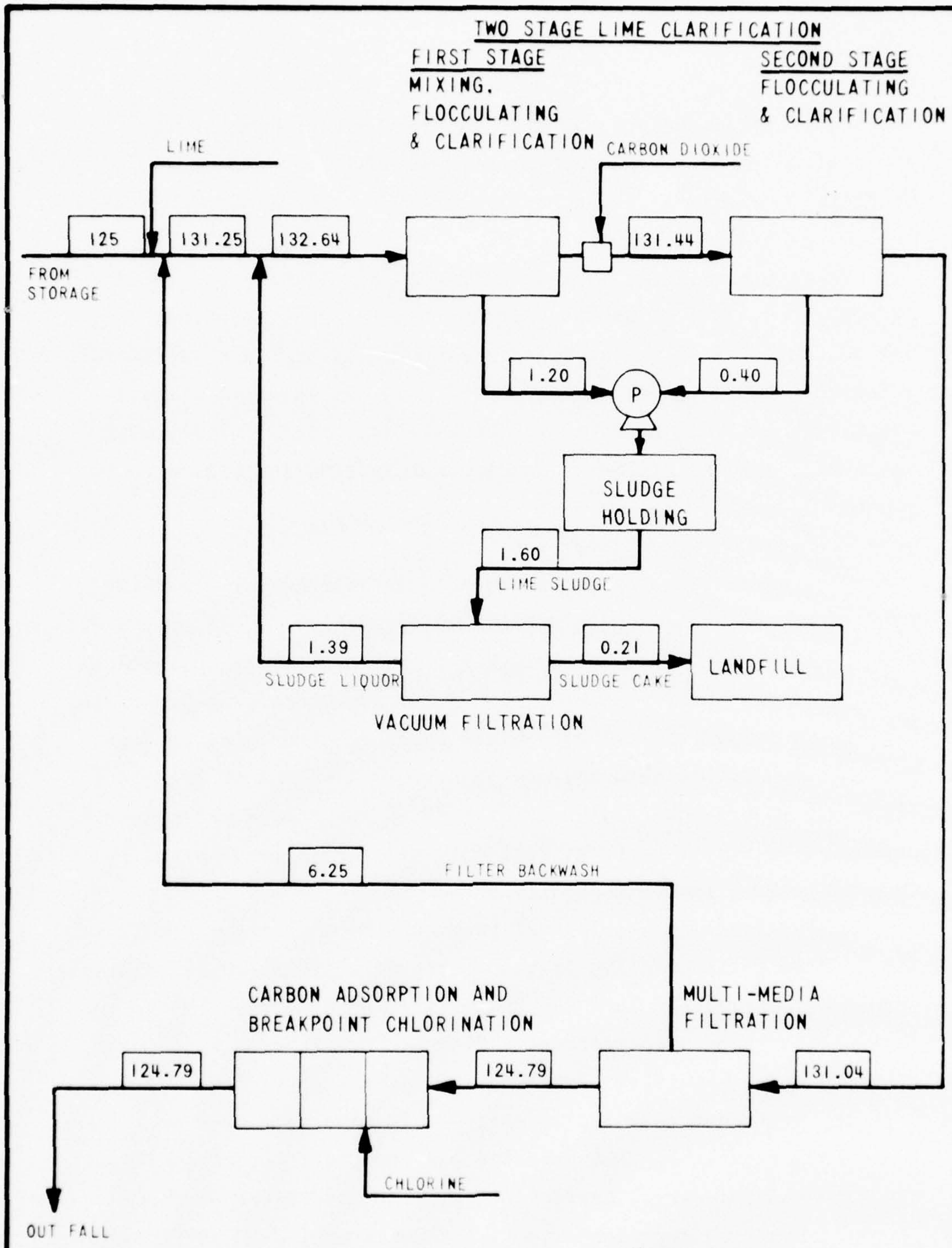
Waste biological sludge is thickened and mixed with primary sludge. The mixed sludge is then chemically conditioned and dewatered on existing vacuum filters with the filter cake hauled to a landfill for disposal. Lime sludge from the chemical clarification process will be dewatered on existing vacuum filters with the sludge cake recalcined. Waste recalcination ash will also be hauled to a landfill.

Recommended Stormwater Treatment Systems

Flow schematics for the seven proposed stormwater treatment facilities are presented in Figures 13 through 19. Cost estimates are developed in Tables 11 through 17. All plants are designed as completely new facilities and all use the same treatment processes. Stormwater is pumped at a controlled rate from temporary storage facilities. It has been assumed that the equivalent of primary treatment is provided at the storage site. Treatment arrangements presented herein, therefore, deal only with the secondary and advanced waste treatment requirements.

Alternatives for biological treatment of the stormwater flow were evaluated in detail. It was concluded that biological systems cannot be operated in a manner that responds satisfactorily to the intermittant nature of stormwater flows. The proposed stormwater treatment plants consist of the following unit processes:

1. Two-stage lime clarification. This unit process is identical to that provided for the treatment of municipal and industrial wastewaters except that recarbonation is not required after the second stage of lime clarification. Adjustment of pH will be accomplished in the breakpoint chlorination process.



FLOW SCHEMATIC

PROPOSED EAST CHINA 125 MGD
STORMWATER TREATMENT PLANT

LEGEND

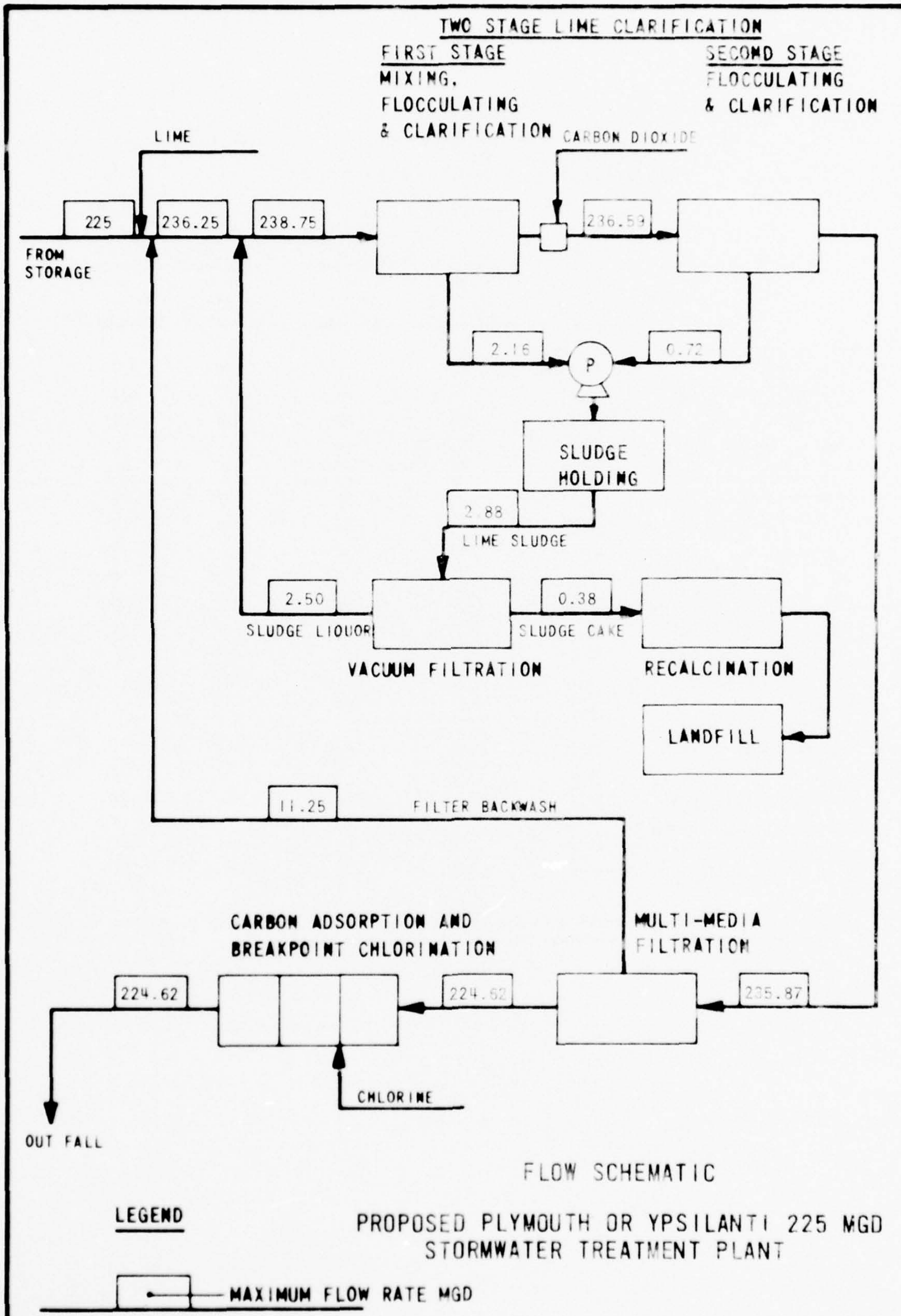
FIGURE 13

TABLE 11

COST ESTIMATE
FOR
125 MGD EAST CHINA STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	6.3	372	--	576	948
Multi-Media Filtration	4.5	266	--	267	533
Carbon Adsorption	18.0	1,063	28	438	1,529
Chlorine Contact Tanks	0.2	14	--	--	14
Chlorination Feed System	0.5	30	--	191	221
Sludge Holding	0.2	12	--	17	29
Vacuum Filtration	0.8	47	12	44	103
Recalcination	--	--	--	--	--
Hauling	0.1	4	5	61	70
Landfill	0.9	50	10	246	306
Instrumentation	0.3	18	--	15	33
Land Required (60 acres)	0.1	5	--	--	5
Site Work and Piping	1.2	71	--	100	171
Garage and Shop	0.2	11	--	--	11
Administration and Laboratory Facilities	0.7	39	--	114	153
Outfall	0.2	12	--	--	12
Total Construction Cost	34.2	2,014	55	2,069	4,138
Engineering, Legal, Administration and Contingencies	10.3	608	--	--	608
Total Project Cost	44.5	2,622	55	2,069	4,746

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 36.3 mgd.



FLOW SCHEMATIC

PROPOSED PLYMOUTH OR YPSILANTI 225 MGD
STORMWATER TREATMENT PLANT

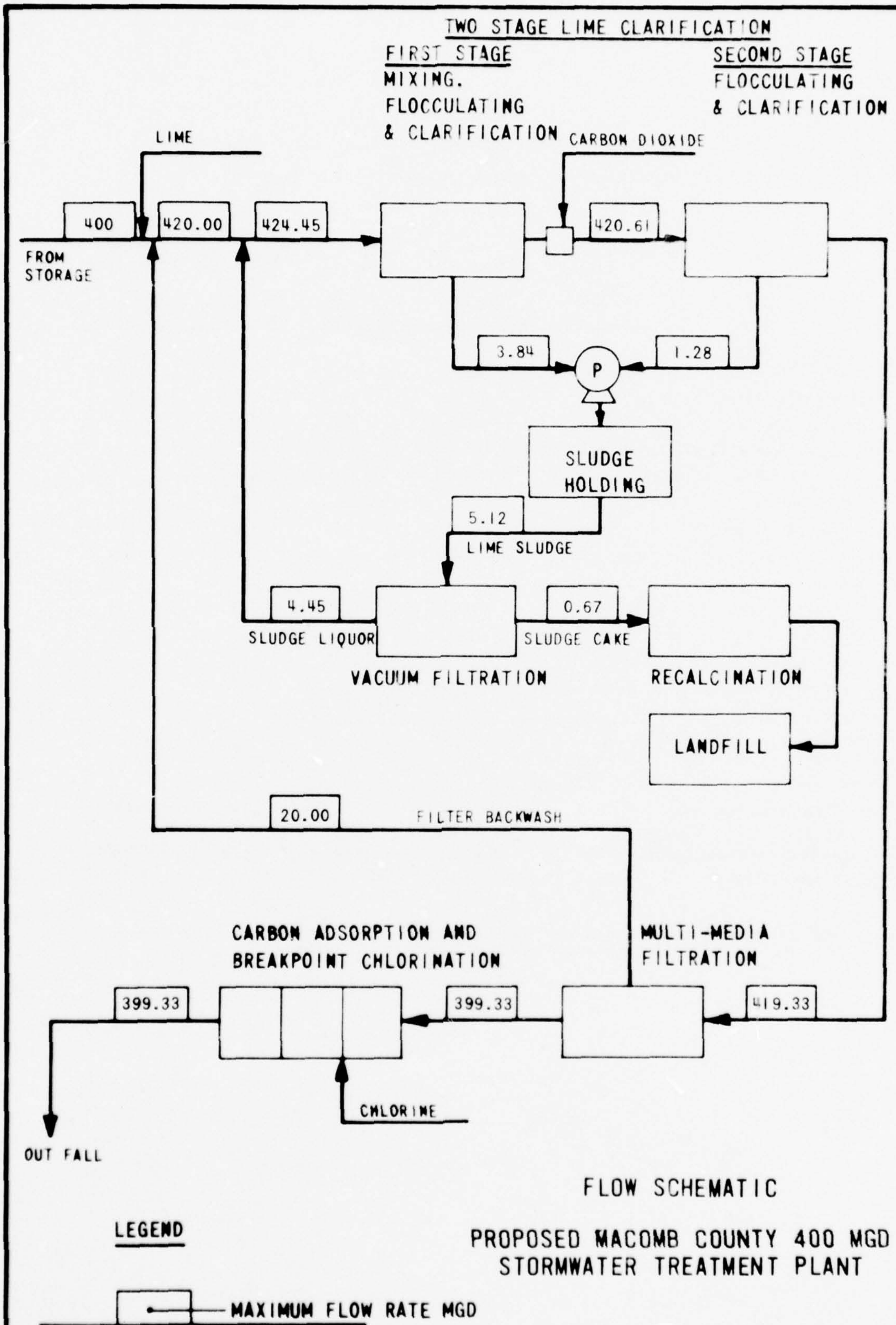
FIGURE 14

TABLE 12

COST ESTIMATE
FOR
225 MGD PLYMOUTH OR YPSILANTI STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	10.6	626	--	983	1,609
Multi-Media Filtration	7.5	443	--	393	836
Carbon Adsorption	30.2	1,784	47	681	2,512
Chlorine Contact Tanks	0.4	24	--	--	24
Chlorination Feed System	0.7	41	--	317	358
Sludge Holding	0.3	18	--	23	41
Vacuum Filtration	1.3	77	20	73	170
Recalcination	1.8	106	28	538	672
Hauling	0.04	2	3	16	21
Landfill	0.2	12	2	61	75
Instrumentation	0.5	30	--	25	55
Land Required (85 acres)	0.1	7	--	--	7
Site Work and Piping	2.1	124	--	156	280
Garage and Shop	0.3	18	--	--	18
Administration and Laboratory Facilities	0.9	53	--	157	210
Outfall	0.1	6	--	--	6
Total Construction Cost	57.0	3,371	100	3,423	6,894
Engineering, Legal, Administration and Contingencies	17.1	1,010	--	--	1,010
Total Project Cost	74.1	4,381	100	3,423	7,904

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 65.3 mgd.



FLOW SCHEMATIC

PROPOSED MACOMB COUNTY 400 MGD
STORMWATER TREATMENT PLANT

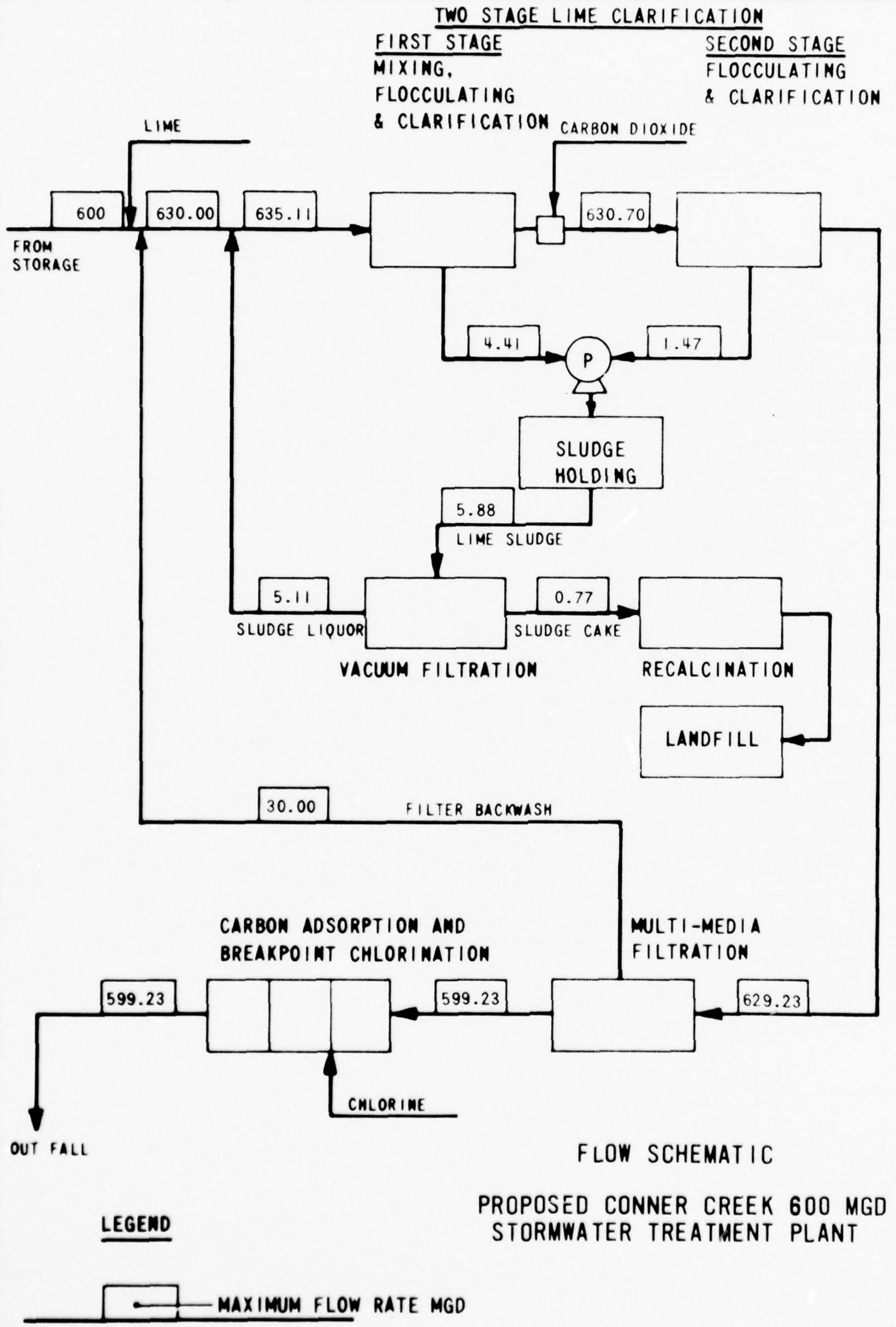
FIGURE 15

TABLE 13

COST ESTIMATE
FOR
400 MGD MACOMB COUNTY STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	17.7	1,045	--	1,677	2,722
Multi-Media Filtration	13.0	768	--	573	1,341
Carbon Adsorption	51.5	3,042	80	1,071	4,193
Chlorine Contact Tanks	0.7	38	--	--	38
Chlorination Feed System	1.0	59	--	536	595
Sludge Holding	0.4	24	--	34	58
Vacuum Filtration	2.1	124	33	121	278
Recalcination	2.4	142	37	776	955
Hauling	0.04	2	3	19	24
Landfill	0.3	18	3	91	112
Instrumentation	0.8	47	--	40	87
Land Required (125 acres)	0.2	10	--	--	10
Site Work and Piping	3.1	183	--	248	431
Garage and Shop	0.4	24	--	--	24
Administration and Laboratory Facilities	1.3	77	--	220	297
Outfall	1.9	112	--	--	112
Total Construction Cost	96.8	5,715	156	5,406	11,277
Engineering, Legal, Administration and Contingencies	29.0	1,713	--	--	1,713
Total Project Cost	125.8	7,428	156	5,406	12,990

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 116 mgd.



FLOW SCHEMATIC

PROPOSED CONNER CREEK 600 MGD
STORMWATER TREATMENT PLANT

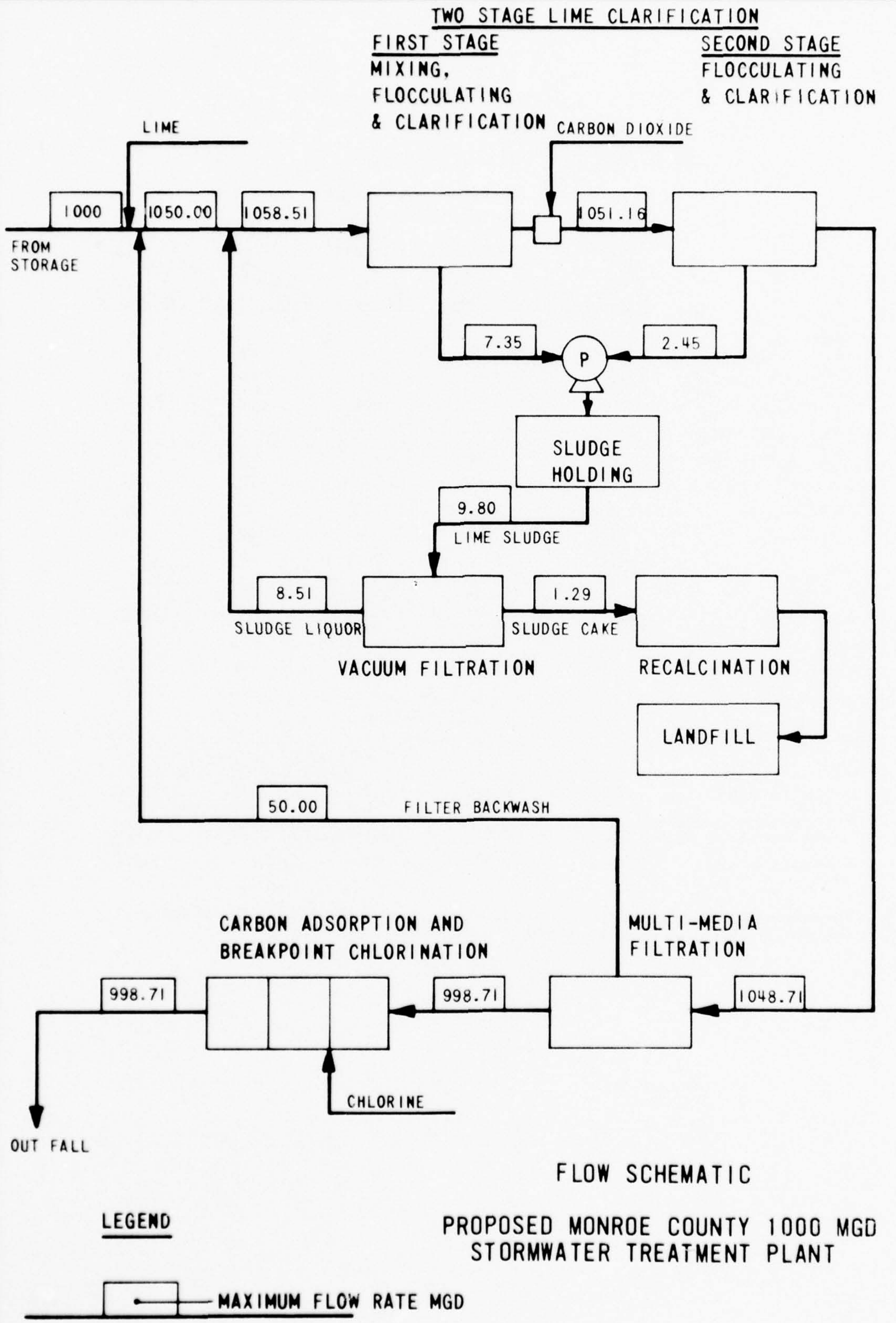
FIGURE 16

TABLE 14

COST ESTIMATE
FOR
600 MGD CONNER CREEK STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year (1)	Total Treatment Cost Thousands of Dollars Per Year (1)
Two Stage Lime Clarification	26.0	1,536	--	2,445	3,981
Multi-Media Filtration	19.5	1,152	--	754	1,906
Carbon Adsorption	75.0	4,430	116	1,537	6,083
Chlorine Contact Tanks	0.9	53	--	--	53
Chlorination Feed System	2.5	148	--	1,670	1,818
Sludge Holding	0.5	30	--	36	66
Vacuum Filtration	2.3	136	36	137	309
Recalcination	2.9	171	45	1,060	1,276
Hauling	0.1	6	7	43	56
Landfill	0.3	18	3	107	128
Instrumentation	1.0	59	--	50	109
Land Required (160 acres)	0.2	13	--	--	13
Site Work and Piping	4.6	272	--	350	622
Garage and Shop	0.5	32	--	--	32
Administration and Laboratory Facilities	1.7	100	--	273	373
Outfall	0.4	24	--	--	24
Total Construction Cost	138.4	8,180	207	8,462	16,849
Engineering, Legal, Administration and Contingencies	41.5	2,451	--	--	2,451
Total Project Cost	179.9	10,631	207	8,462	19,300

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 174 mgd.



FLOW SCHEMATIC

PROPOSED MONROE COUNTY 1000 MGD
STORMWATER TREATMENT PLANT

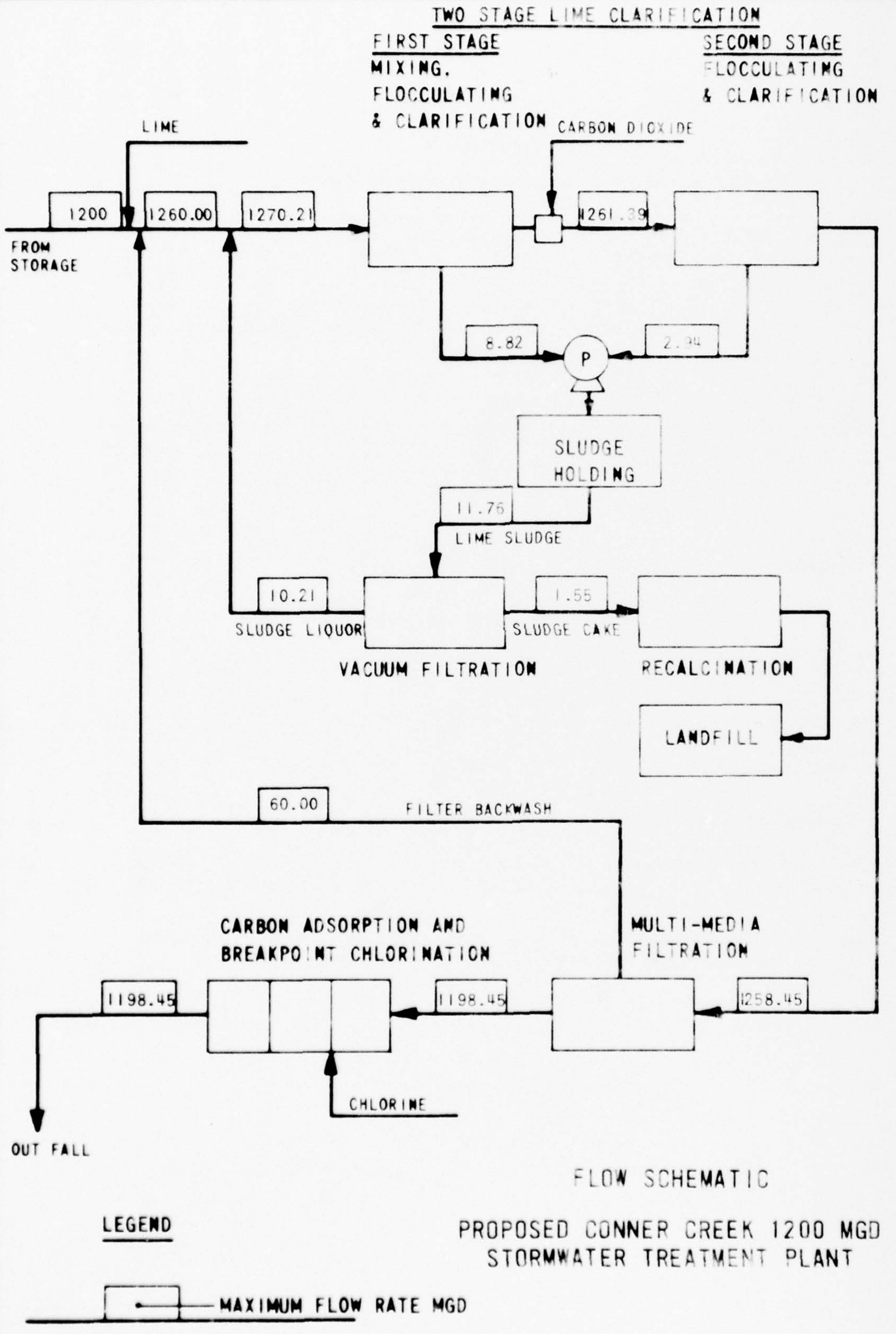
FIGURE 17

TABLE 15

COST ESTIMATE
FOR
1,000 MGD MONROE COUNTY STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	42.0	2,481	--	3,959	6,440
Multi-Media Filtration	33.0	1,949	--	1,071	3,020
Carbon Adsorption	122.0	7,205	189	2,387	9,781
Chlorine Contact Tanks	1.4	83	--	--	83
Chlorination Feed System	3.6	213	--	2,783	2,996
Sludge Holding	0.7	41	--	53	94
Vacuum Filtration	3.7	219	57	219	495
Recalcination	3.7	219	57	1,710	1,986
Hauling	0.1	6	7	40	53
Landfill	0.5	30	6	149	185
Instrumentation	1.3	77	--	65	142
Land Required (220 acres)	0.3	18	--	--	18
Site Work and Piping	6.3	372	--	548	920
Garage and Shop	0.8	47	--	--	47
Administration and Laboratory Facilities	2.3	136	--	370	506
Outfall	2.3	136	--	--	136
Total Construction Cost	224.0	13,232	316	13,354	26,902
Engineering, Legal, Administration and Contingencies	67.2	3,970	--	--	3,970
Total Project Cost	291.2	17,202	316	13,354	30,872

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 290 mgd.



FLOW SCHEMATIC

PROPOSED CONNER CREEK 1200 MGD
STORMWATER TREATMENT PLANT

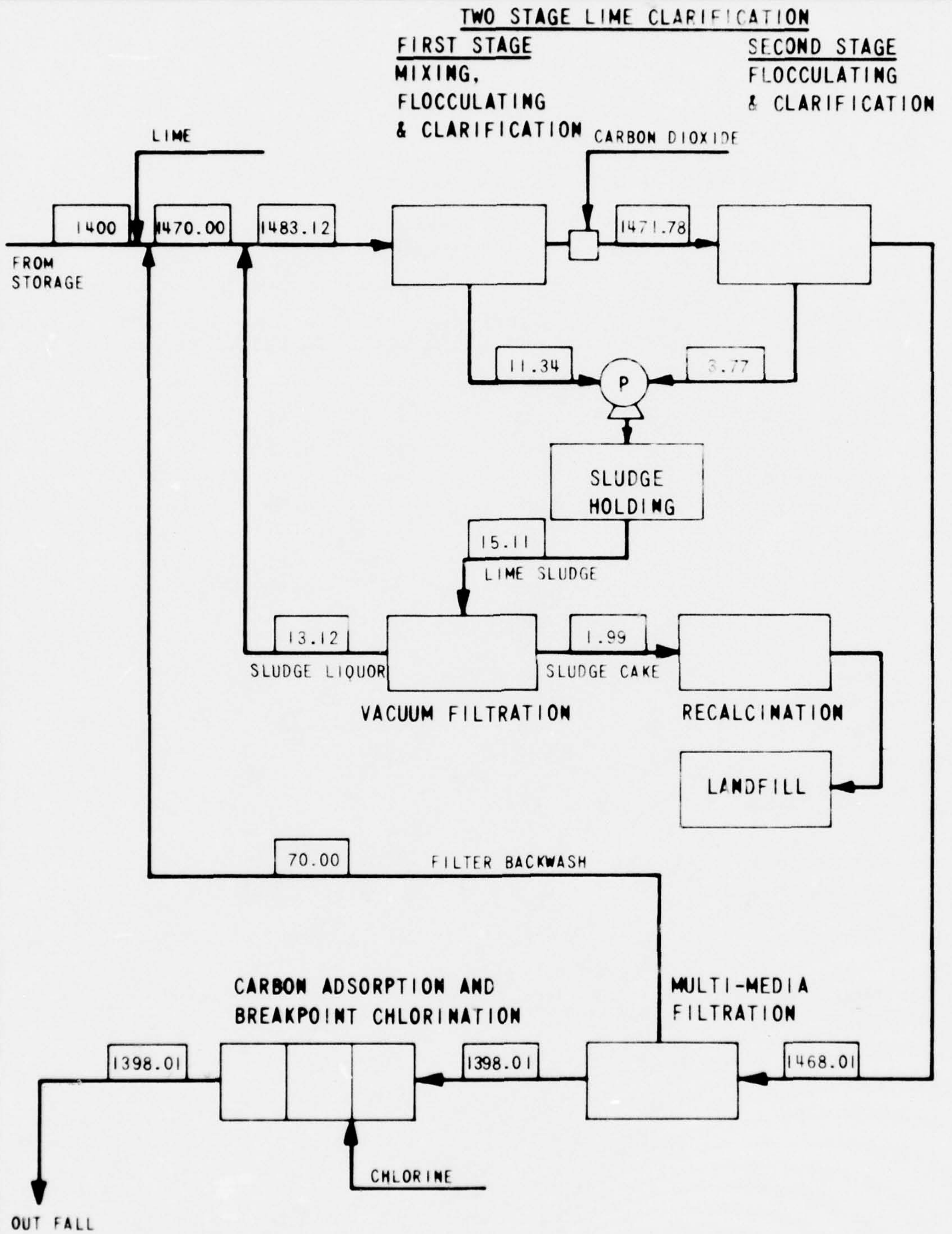
FIGURE 18

TABLE 16

COST ESTIMATE
FOR
1,200 MGD CONNER CREEK STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	50.2	2,965	--	4,751	7,716
Multi-Media Filtration	40.0	2,362	--	1,244	3,606
Carbon Adsorption	144.0	8,505	223	2,753	11,481
Chlorine Contact Tanks	1.7	100	--	--	100
Chlorination Feed System	4.2	248	--	3,269	3,517
Sludge Holding	0.8	46	--	60	106
Vacuum Filtration	4.3	254	67	256	577
Recalcination	4.2	248	65	2,050	2,363
Hauling	0.1	6	7	86	99
Landfill	0.5	30	6	168	204
Instrumentation	1.5	86	--	75	161
Land Required (250 acres)	0.3	20	--	--	20
Site Work and Piping	7.5	443	--	613	1,056
Garage and Shop	0.9	54	--	--	54
Administration and Laboratory Facilities	2.6	154	--	406	560
Outfall	0.7	41	--	--	41
Total Construction Cost	263.5	15,562	368	15,731	31,661
Engineering, Legal, Administration and Contingencies	79.1	4,672	--	--	4,672
Total Project Cost	342.6	20,234	368	15,731	36,333

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 348 mgd.



FLOW SCHEMATIC

PROPOSED MONROE COUNTY 1400 MGD
STORMWATER TREATMENT PLANT

LEGEND

MAXIMUM FLOW RATE MGD

FIGURE 19

TABLE 17

COST ESTIMATE
FOR
1,400 MGD MONROE COUNTY STORMWATER TREATMENT PLANT

	Construction Cost Millions of Dollars	Amortized Construction Cost Thousands of Dollars Per Year	Amortized Replacement Cost Thousands of Dollars Per Year	Operation and Maintenance Thousands of Dollars Per Year(1)	Total Treatment Cost Thousands of Dollars Per Year(1)
Two Stage Lime Clarification	59.0	3,485	--	5,461	8,946
Multi-Media Filtration	44.0	2,599	--	1,386	3,985
Carbon Adsorption	165.0	9,745	256	3,113	13,114
Chlorine Contact Tanks	1.9	112	--	--	112
Chlorination Feed System	3.4	201	--	2,510	2,711
Sludge Holding	0.9	56	--	74	130
Vacuum Filtration	5.5	325	85	323	733
Recalcination	4.7	278	73	2,320	2,671
Hauling	0.1	6	7	48	61
Landfill	0.6	35	7	194	236
Instrumentation	1.4	83	--	70	153
Land Required (275 acres)	0.4	22	--	--	22
Site Work and Piping	8.6	508	--	664	1,172
Garage and Shop	1.0	59	--	--	59
Administration and Laboratory Facilities	2.8	165	--	445	610
Outfall	2.8	165	--	--	165
Total Construction Cost	302.1	17,844	428	16,608	34,880
Engineering, Legal, Administration and Contingencies	90.6	5,351	--	--	5,351
Total Project Cost	392.7	23,195	428	16,608	40,231

(1) The operation and maintenance cost and total treatment cost in thousands of dollars per year are based on the average yearly flow rate of 406 mgd.

2. Multi-media filtration. This process is also the same as proposed for the municipal and industrial wastewater flow. The units will provide only solids removal, however; methanol will not be added and denitrification will not be accomplished in the filtration step.
3. Activated carbon adsorption. A two-stage carbon adsorption process is proposed with breakpoint chlorination provided between the two stages. The carbon adsorption will provide the desired degree of removal of soluble organics. Breakpoint chlorination will eliminate ammonia nitrogen. The second stage of carbon adsorption is required to remove toxic chloramine generated by chlorination. Breakpoint chlorination will also lower the pH of the wastewater from approximately 9.5 to slightly over 6.0.

Sludge handling at all of the plants consists of vacuum filtration of the lime sludge. The filter cake will be recalcined to recover part of the lime at all plants with the exception of East China. Waste ash from the recalcination furnaces will be hauled to a landfill for disposal. At the East China plant dewatered sludge will be hauled directly to landfill. Filtrate from the dewatering process and backwash from multi-media filters will be returned to the wastewater flow ahead of the two-stage lime clarification process.

Design Criteria

The efficiency of a particular unit process is dependent upon the rate at which that process is loaded. Unit loading rates for this study were developed to optimize the treatment capabilities of each unit process in an effort to meet specified effluent criteria at the lowest possible cost. Design criteria for the various unit processes were developed for each location and are presented in Tables 18 through 21.

A brief discussion of the rationale for the selection of the unit loading criteria for each unit process follows:

Raw Waste Pumping - The firm capacity with the largest pump out of service was designed to equal the expected peak flow rate into the treatment facility.

TABLE 18

DESIGN CRITERIA THROUGH SECONDARY TREATMENT

FOR

MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Adrian	Port Huron	Monroe	Wayne County	Mouth of Huron River	Mouth of Huron River	Detroit
Design Flows							
Average Flow, mgd	12	24	40	125	400	525	806
Peak Flow, mgd	30	48	80	188	560	735	1,130
Raw Waste Pumping							
Firm Capacity, mgd	30	68	44	200	560	735	1,200
Preliminary Treatment							
Peak Flow Rate, mgd	30	60	44	200	560	735	1,200
Primary Clarifiers							
Flow Rate, mgd	12	24	22	125	400	525	806
Total Surface Area, 1,000 ft^2	12	26.4	22	125	400	525	806
Overflow Rate, gpd/ft^2	1,000	910	1,000	1,000	1,000	1,000	1,000
Aeration				Pure Oxygen			
Flow Rate, mgd	12.1	24	40.3	126	403	529	811
Detention Time, hours	4	4	4	1.5	4	4	4
Tank Volume, 1,000 ft^3	270	535	900	1,050	8,980	11,785	18,100
BOD Applied, mg/l	146	86	113	86	86	86	86
Volumetric Loading, lb BOD_5/1,000 ft^3/day	54.6	32.2	42.2	85.8	32.2	32.2	32.2
Air Requirements, ft^3/lb BOD_5	1,500	1,500	1,500	--	1,500	1,500	1,500
Firm Blower Capacity, 1,000 cfm	15.2	17.9	39.3	--	299	395	600
Secondary Clarifiers							
Flow Rate, mgd	12	24	40	125	400	525	806
Total Surface Area, 1,000 ft^2	15	33.6	50	156	500	656	1,010
Overflow Rate, gpd/ft^2	800	715	800	800	800	800	800

TABLE 19

DESIGN CRITERIA FOR ADVANCED WASTEWATER TREATMENT PROCESSES

FOR

MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Adrian	Port Huron	Monroe	Wayne County	Mouth of Huron River	Mouth of Huron River	Detroit
Nitrification							
Flow Rate, mgd	12	24	40	125	400	525	806
Detention Time, hours	5	4	4	3	3	3	3
Tank Volume, 1,000 ft^3	335	535	892	2,089	6,690	8,780	13,500
NH_3-N Applied, mg/l	8.2	5.8	6.1	5.8	5.8	5.8	5.8
BOD Applied, mg/l	23	13	17	13	13	13	13
Oxygen Demand, 1,000 lb/day	12.9	14.6	27.2	62.1	190	249	383
Firm Blower Capacity, 1,000 cfm	20.5	23.2	43.2	99	302	396	609
Clarifiers							
Flow Rate, mgd	12	24	40	125	400	525	806
Total Surface Area, 1,000 ft^2	15	30	50	156	500	656	1,010
Overflow Rate, gpd/ft^2	800	800	800	800	800	800	800
First Stage Lime Clarification							
Flow Rate, mgd	12.6	25.2	42	131	420	551	846
Total Surface Area, 1,000 ft^2	12.6	25.2	42	131	420	551	846
Overflow Rate, gpd/ft^2	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Lime Dosage, mg/l	200	200	200	200	200	200	200
Second Stage Lime Clarification							
Flow Rate, mgd	12.6	25.2	42	131	420	551	845
Total Surface Area, 1,000 ft^2	10.5	18.0	30	94	300	394	604
Overflow Rate, gpd/ft^2	1,200	1,400	1,400	1,400	1,400	1,400	1,400
Multi-Media Filtration-Denitrification							
Peak Flow Rate, mgd	31.5	50.3	84	197	587	771	1,185
Filtration Rate at Peak Flow, gpm/ft^2	5	5	5	5	5	5	5
Filter Surface Area, 1,000 ft^2	4.4	7.0	11.7	27.3	82	107	164
Methanol Required, mg/l	42	35	24	35	35	35	35
Chlorination							
Peak Flow Rate, mgd	30	48	80	188	559	734	1,129
Detention Time at Peak Flow, min.	15	15	15	15	15	15	15
Carbon Adsorption							
Average Flow Rate, mgd	12	24	40	125	400	525	805
Carbon Contact Time at Average Flow, min.	20	20	20	17	17	17	17

TABLE 20

DESIGN CRITERIA FOR SLUDGE PROCESSING SYSTEMS

FOR

MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Adrian	Port Huron	Monroe	Wayne County	Mouth of Huron River	Mouth of Huron River	Detroit
Average Flow, mgd	12	24	40	125	400	525	806
Sludge Holding							
Volume, 1,000 ft^3	17.8	Use Existing	123	224	537	704	1,084
Flotation Thickening Waste Biological Sludge							
Sludge Applied, ton/day (dry weight)	5.1	18.5	17.2	37	118	155	237
Surface Loading Rate, $lb/ft^2/day$	14.4	Existing	14.4	Use	14.4	14.4	14.4
Total Surface Area, ft^2	710	Gravity Thickener	2,500	Existing Tanks	16,400	21,500	33,000
Thermal Conditioning Primary and Waste Biological Sludge							
Sludge Applied, ton/day (dry weight)	12.7	18.5	--	--	--	--	--
Chemical Conditioning Primary and Waste Biological Sludge							
Sludge Applied, ton/day (dry weight)	--	--	27.6	96	308	404	620
Vacuum Filtration							
Primary and Waste Biological Sludge							
Sludge Applied, ton/day (dry weight)	12.7	18.5	27.6	96	308	404	620
Filtration Rate, $lb/hr/ft^2$	13	Use Existing	3.5	4.5	4.5	4.5	4.5
Filter Area, ft^2	150	Centrifuges	970	4,000	7,100	9,300	14,300
Chemical Clarification Sludge							
Sludge Applied, ton/day (dry weight)	13.3	26.6	42.3	139	443	582	895
Filtration Rate, $lb/hr/ft^2$	30	30	30	30	30	30	30
Filter Area, ft^2	100	150	150	2,000	1,540	2,030	3,800
Incineration of Primary and Waste Biological Sludge							
Incinerator Capacity, ton/day (dry weight)	--	--	27.6	274	--	--	--
Recalcination							
Sludge Applied, ton/day (dry weight)	--	--	--	139	443	582	895
Hauling to Landfill							
Sludge to be Hauled, yd^3/day	68.0	117	119.9	90.5	1,300	1,707	2,616
Size of Truck, yd^3	10	10	30	30	30	30	30
Distance to Landfill, miles	10	15	25	45	35	35	50
Trips per Truck per 8 hour shift	8	5	4	3	4	4	3
Number of Trucks Required	1	3	2	2	6	8	16
Landfill							
Sludge Applied, yd^3/day	68.0	117	119.9	90.5	1,300	1,707	2,616
Land Required for 50 Years, acres	64.0	119	112.4	85	1,213	1,588	2,437

TABLE 21

DESIGN CRITERIA

FOR

STORMWATER TREATMENT PLANTS

	East China	Plymouth or Ypsilanti	Macomb County	Conner Creek	Monroe County	Conner Creek	Monroe County
Maximum Treatment Rate, mgd	125	225	400	600	1,000	1,200	1,400
First Stage Lime Clarification							
Maximum Flow Rate, mgd	131	237	421	631	1,051	1,261	1,472
Total Surface Area, 1,000 ft^2	93.6	169.2	301	451	752	902	1,052
Overflow Rate at Peak Flow, gpd/ft^2	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Lime Dosage, mg/l	200	200	200	200	200	200	200
Second Stage Lime Clarification							
Maximum Flow Rate, mgd	131	236	419	629	1,049	1,258	1,468
Total Surface Area, 1,000 ft^2	65.5	118	209.5	314.5	524.5	629	734
Overflow Rate at Peak Flow, gpd/ft^2	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Multi-Media Filtration							
Maximum Flow Rate, mgd	131	236	419	629	1,049	1,258	1,468
Filtration Rate at Peak Flow, gpm/ft^2	5	5	5	5	5	5	5
Filter Surface Area, 1,000 ft^2	18.2	32.8	58.1	87.4	145.8	174.8	204.0
First Stage Carbon Adsorption							
Maximum Flow Rate, mgd	125	225	399	599	999	1,198	1,398
Carbon Contact Time at Peak Flow, min.	10	10	10	10	10	10	10
Breakpoint Chlorination							
Maximum Flow Rate, mgd	125	225	399	599	999	1,198	1,398
Detention Time at Peak Flow, min.	15	15	15	15	15	15	15
Second Stage Carbon Adsorption							
Maximum Flow Rate, mgd	125	225	399	599	999	1,198	1,398
Carbon Contact Time at Peak Flow, min.	10	10	10	10	10	10	10
Sludge Holding							
Volume, 1,000 ft^3	107	192	341	393	655	782	1,010
Vacuum Filtration of Lime Sludge							
Sludge Applied at Maximum Flow, ton/day (Dry Weight)	333	600	1,067	1,226	2,043	2,452	3,150
Filtration Rate, lb/hour/ft^2	30	30	30	30	30	30	30
Filter Area, ft^2	1,160	2,080	3,710	4,250	7,110	8,520	10,900
Recalcination							
Sludge Applied at Maximum Flow, ton/day (Dry Weight)	--	600	1,067	1,226	2,043	2,452	3,150
Hauling to Landfill							
Sludge to be Hauled at Maximum Flow, yd^3/day	880	106	188	247	412	495	617
Distance to Landfill, miles	20	25	25	50	25	50	25
Trips per Truck per 8 Hour Shift	6	6	6	3	6	3	6
Number of 30 C.Y. Trucks Required	2	1	1	2	2	4	2
Landfill							
Sludge Applied at Mean Yearly Average Flow Rate, yd^3/day	255	31	55	72	120	144	179
Land Required for 50 Years, acres	240	29	51	67	113	136	166

Preliminary Treatment - Preliminary treatment includes screening, grit removal, and metering of the raw wastewater. These facilities are all designed for operation at the anticipated peak flow rate.

Clarification Tanks - Surface settling area, and to a lesser extent detention time, influence the performance of sedimentation tanks in removing solids from wastewater. The overflow rate, which in effect is the average upflow velocity, is the parameter most commonly used for design. For this study, a surface overflow rate of 1,000 gallons per day per square foot at the design average flow rate was used for primary clarification tanks. This provides an average detention time of approximately two hours.

Clarification tanks following the aeration and nitrification processes were designed with an overflow rate of 800 gallons per day per square foot, and a detention time of approximately 2 1/2 hours.

Aeration - The design parameter most frequently utilized for aeration tanks is the ratio of incoming BOD_5 to active bio-mass. Within the normal range of influent wastewater characteristics exhibited at plants throughout the study area, specification of detention time adequately establishes unit sizes. Aeration tanks were designed on the complete-mix principle with a detention time of 4 hours at average flow and a volumetric loading not exceeding 60 pounds of BOD_5 per 1,000 cubic feet per day. Air blowers were sized to deliver 1,500 cubic feet of air per pound of BOD_5 applied.

Nitrification - Nitrification tanks are very similar in construction features to aeration tanks. The detention time depends upon the BOD_5 and ammonia nitrogen in the influent, as well as the minimum operating temperature and the pH of the mixed liquor. Air requirements depend mainly upon the ammonia nitrogen and the BOD_5 in the influent. Detention times and air requirements were calculated individually for each plant.

Two-stage Lime Clarification - For the municipal and industrial wastewater treatment plants, an overflow rate of 1,000 gallons per day per square foot has been utilized for the first stage and 1,400 gallons per day per square foot for the second stage based

on the design average flow rate. For the stormwater treatment plants overflow rates were established at 1,400 gallons per day per square foot for the first stage and 2,000 gallons per day per square foot for the second stage, based on the peak treatment rate. The higher overflow rates for the second stage clarifiers have been utilized because particles escaping the process will be captured in the multi-media filters which follow.

Multi-media Filtration - Multi-media filtration for the stormwater and multi-media filtration with denitrification for the municipal and industrial waste flow are both designed with a filtration rate of 5 gallons per minute per square foot at the peak flow rate.

Chlorination - All chlorination facilities were designed to provide a contact time of 15 minutes at the peak flow rate. The chlorination feed systems at all municipal-industrial and stormwater treatment plants were designed with capacity for breakpoint chlorination of ammonia nitrogen. The facilities were sized to provide 10 milligrams per liter of chlorine for each milligram per liter of ammonia nitrogen anticipated.

Carbon Adsorption - The carbon contact times used for design of the municipal and industrial wastewater treatment plants range from 17 minutes for the larger plants to 20 minutes for the smaller plants, based on the average flow rate. The carbon contact time for the stormwater treatment plants was 10 minutes for each of the two stages. It is estimated that the carbon exhaustion rate will be about 250 to 300 pounds per million gallons for both the stormwater and the municipal-industrial wastewater treatment plants.

Flotation Thickening - Flotation thickeners will be used to thicken waste biological sludge from approximately 1 percent solids to about 2 1/2 percent. The thickening tanks have been designed with a surface loading rate of 14.4 pounds per square foot per day.

Sludge Holding - Sludge holding facilities at the municipal and industrial wastewater treatment plants will be provided to hold

a minimum of one days' sludge production. At the stormwater treatment plants, similar tanks will hold 12 hours sludge production at the peak flow rate.

Chemical Conditioning - Primary and waste biological sludge is chemically conditioned with lime and ferric chloride prior to vacuum filtration to improve dewaterability. Chemical dosages have been estimated to be 11 pounds of lime and 3 pounds of ferric chloride per 100 pounds of dry sludge solids.

Thermal Conditioning - Thermal conditioning of primary and waste biological sludge in certain applications provides a material which is easily dewatered. Thermal conditioning will increase the sludge solids content from about 4 percent to approximately 6 1/2 percent.

Vacuum Filtration - The filtration rates used for design of facilities is 4.5 pounds per hour per square foot for chemically conditioned sludge and 13 pounds per hour per square foot for thermally conditioned primary and waste biological sludge. A filtration rate of 30 pounds per hour per square foot has been used for lime sludge.

Incineration and Recalcination - Furnaces to incinerate primary and waste biological sludge and to recalcine lime sludge will be of the multiple hearth type. The furnaces will be equipped with exhaust gas scrubbers for air pollution control.

Transportation - Trucks with capacities from 10 to 30 cubic yards have been assumed for hauling sludge cake and incinerator ash to landfills for disposal. At the four smallest municipal and industrial wastewater treatment plants, the sludge can be hauled during one 8-hour shift each day. At the Mouth of the Huron River and Detroit plants, the trucks will need to operate 16 hours per day.

At the stormwater treatment plants, enough trucks have been provided to haul the sludge during one 8-hour shift per day when the plant is operating at 50 percent of maximum capacity. During peak operating periods trucks may have to operate up to 16 hours per day.

Outfall Analysis

The effluent from the proposed wastewater treatment plants in the study area will generally be of higher quality than the receiving waters. Discharge facilities will disperse the treated effluent and provide uniform mixing to minimize temperature effects.

A preliminary outfall design has been developed for each stormwater treatment plant and each new municipal-industrial facility. The estimated peak flow rate, outfall pipe size, and length of diffuser pipe is presented in Table 22.

System Reliability and Performance

A reliable treatment system must contain safeguards to avoid the discharge of inadequately treated wastewater, even when a part of the entire system is not functioning as intended.

A combination of unit processes has been incorporated into the design of the proposed wastewater treatment systems which will provide a high degree of system performance reliability. Extensive use has been made of flexible unit operations, thus providing the capability for removal of objectionable constituents in more than one process. Treatment units will be integrated into the total treatment system in such a manner that an individual unit can be taken out of service for repair or maintenance with the normal flow being distributed to the other units. Computer control and operation of each plant is recommended with extensive use of instrumentation to monitor the flow and quality of the wastewater after each major treatment process. The arrangement of the unit processes offers a certain degree of reliability. If, for example, the aeration process is upset and out-of-service, overall BOD and COD removals approaching desired goals should still be expected. Also, breakpoint chlorination can be used to remove nitrogen from the wastewater if the biological nitrification-denitrification facilities at the municipal-industrial treatment facilities are not functioning properly. Good preventive maintenance programs should minimize downtime due to equipment repairs. It is also anticipated that the wastewater treatment plants will be connected to more than one source of power.

TABLE 22

PROPOSED EFFLUENT DISCHARGE FACILITIES

	Peak Flow Rate, cfs	Outfall Pipe Diameter, inches	Length of Diffuser Pipe
Municipal and Industrial Wastewater Treatment Plants			
Adrian (12 mgd)	47	42	100
Port Huron (24 mgd)	75		*
Monroe (40 mgd)	124		*
Wayne County (125 mgd)	291		*
Mouth of Huron River (400 mgd)	866	120	1,000
Mouth of Huron River (525 mgd)	1,140	126	1,000
Detroit (806 mgd)	1,750		*
Stormwater Treatment Plants			
East China (125 mgd)	195	72	100
Plymouth or Ypsilanti (225 mgd)	350	78	100
Macomb County (400 mgd)	620	126	1,000
Conner Creek (600 mgd)	930	120	1,000
Monroe County (1,000 mgd)	1,550	2 x 126	1,000
Conner Creek (1,200 mgd)	1,860	2 x 120	1,000
Monroe County (1,400 mgd)	2,170	2 x 144	1,000

* Use Existing Facilities.

The performance of a system depends upon reliability and the removal efficiency of each unit process. The effluent quality after each unit process has been estimated for each treatment plant and is presented in Tables 23 and 24.

Multiple Use Opportunities

Landfills were costed on the basis of one location for each wastewater treatment plant. A cost saving could be achieved for the smaller plants if large joint landfill facilities were constructed at two disposal areas. The largest of the two landfill areas would be near either tecumseh or Adrian. This landfill would serve all plants except Port Huron, Macomb County, and East China Township. The smaller landfill serving those three plants would be located near Emmet.

Waste recalcination ash and incinerator ash could be deposited in sanitary landfills used for refuse disposal if the solids content could be maintained consistently above 50 percent. However, it is recommended that the ash be kept separate from refuse in landfill disposal operations.

For cost estimating purposes, each plant with lime recalcination was considered to have its own facilities. It is recommended that after the final selection of plant combinations, two or three large centrally located recalcination facilities be constructed at stormwater plants. Dewatered lime sludge or lime slurry from other stormwater and nearby municipal and industrial wastewater treatment facilities could be hauled or pumped to these facilities for recalcination. If the major recalcination plants were sized to handle the peak rates from the stormwater treatment plants, they could also be used to produce lime from crushed limestone during periods of low stormwater flow. Additional lime calcination facilities

TABLE 23

ESTIMATED UNIT PROCESS EFFLUENT QUALITY
FOR
MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Raw Wastewater	Primary	Secondary	Nitrification	Chemical Clarification	Multi-Media Filtration and Denitrification	Chlorination and Granular Carbon Adsorption
BOD_5, mg/l	132	86	13	10	5	3	1
COD, mg/l	350	228	70	60	35	25	10
Suspended Solids, mg/l	226	113	23	20	10	1	1
Volatile Suspended Solids, mg/l	158	95	16	14	--	--	--
Phosphorous -P, mg/l	11.7	10.5	8.2	8.2	0.4	0.2	0.2
Ammonia -N, mg/l	7.5	11.3	5.8	0.5	0.5	0.4	0.4
Organic-N, mg/l	13.3	7.6	1.1	0.5	0.5	0.5	0.5
Nitrites and Nitrates -N, mg/l	0.053	0.053	6.5	11.4	11.4	1.2	1.2
Copper, mg/l	0.36	0.32	0.18	0.18	0.12	0.05	0.005
Cadmium, mg/l	0.015	0.015	0.013	0.013	0.002	0.002	0.00[illegible]
Nickle, mg/l	0.52	0.47	0.38	0.38	0.19	0.10	0.05
Zinc, mg/l	0.44	0.40	0.10	0.10	0.08	0.05	0.005
Lead, mg/l	0.16	0.16	0.14	0.14	0.10	0.05	0.01
Phenols, µg/l	588	530	29	29	25	25	10
Oil and Grease, mg/l	71	44	36	33	26	2	1

Note: Applies to following plants:
Port Huron (24 mgd)
Wayne County (125 mgd)
Mouth of Huron River (400 mgd)
Mouth of Huron River (525 mgd)
Detroit (806 mgd)

TABLE 23 (Continued)

ESTIMATED UNIT PROCESS EFFLUENT QUALITY

FOR

MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Raw Wastewater	Primary	Secondary	Nitrification	Chlorination and Chemical Clarification	Multi-Media Filtration and Denitrification	Granular Carbon Adsorption
BOD_5, mg/l	225	146	23	15	6	3	1
COD, mg/l	500	325	100	85	35	25	10
Suspended Solids, mg/l	300	150	30	25	10	1	1
Volatile Suspended Solids, mg/l	250	125	25	--	--	--	--
Phosphorous -P, mg/l	13	11.7	9	9.0	0.5	0.2	0.2
Ammonia -N, mg/l	10	14.8	8.2	0.6	0.6	0.4	0.4
Organic-N, mg/l	15	7.8	1.1	0.5	0.5	0.5	0.5
Nitrites and Nitrates -N, mg/l	0.4	0.4	7.1	13.9	13.9	1.4	1.4
Cyanide, mg/l	1.0	0.9	0.5	0.4	0.04	0.04	0.02
Copper, mg/l	0.5	.45	0.2	0.2	0.07	0.05	0.005
Cadmium, mg/l	0.015	0.015	0.013	0.013	0.002	0.002	0.001
Nickle, mg/l	0.5	0.45	0.4	0.4	0.15	0.10	0.05
Zinc, mg/l	0.5	0.45	0.1	0.1	0.08	0.05	0.005
Lead, mg/l	0.2	0.2	0.2	0.2	0.06	0.05	0.01
Oil and Grease, mg/l	45	28	23	21	18	2	1

Note: Applies to Adrian Plant (12 mgd).

TABLE 23 (Continued)

ESTIMATED UNIT PROCESS EFFLUENT QUALITY

FOR

MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Raw Wastewater	Primary	Secondary	Nitrification	Chemical Clarification	Multi-Media Filtration and Denitrification	Chlorination and Granular Carbon Adsorption
BOD_5, mg/l	174	113	17	13	5	3	1
COD, mg/l	348	226	70	60	35	25	10
Suspended Solids, mg/l	143	72	14	12	10	1	1
Volatile Suspended Solids, mg/l	100	60	10	--	--	--	--
Phosphorus -P, mg/l	13	11.7	9.1	9.1	0.5	0.2	0.2
Ammonia -N, mg/l	11.3	11.4	6.1	0.5	0.5	0.3	0.3
Organic-N, mg/l	3.1	1.7	0.3	0.2	0.2	0.2	0.2
Nitrites and Nitrates -N, mg/l	0.011	0.011	2.9	7.9	7.9	1.0	1.0
Copper, mg/l	0.07	0.06	0.04	0.04	0.02	0.01	0.005
Nickle, mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc, mg/l	0.05	0.05	0.03	0.03	0.03	0.02	0.005
Lead, mg/l	0.13	0.13	0.12	0.12	0.06	0.05	0.01
Phenols, µg/l	40	36	2	2	2	2	1
Oil and Grease, mg/l	43	27	22	20	16	2	1

Note: Applies to Monroe Plant (40 mgd).

TABLE 24

ESTIMATED UNIT PROCESS EFFLUENT QUALITY

FOR STORMWATER TREATMENT PLANTS

	Pumped From Storage	Chemical Clarification	Multi-Media Filtration	Granular Carbon Adsorption	Breakpoint Chlorination
East China (125 mgd)					
Plymouth or Ypsilanti (225 mgd)					
Macomb County (400 mgd)					
BOD_5, mg/l	30	12	7	2	2
COD, mg/l	90	35	25	10	10
Suspended Solids, mg/l	400	40	4	4	4
Volatile Suspended Solids, mg/l	160	--	--	--	--
Phosphorous -P, mg/l	6	0.2	0.1	0.1	0.1
Ammonia -N, mg/l	3	3	3	3	0.5
Nitrites and Nitrates -N, mg/l	1.5	1.5	1.5	1.5	1.5
Oil and Grease, mg/l	20	15	2	1	1
Conner Creek (600 and 1,200 mgd)					
Monroe County (1,000 mgd)					
BOD_5, mg/l	45	20	11	2	2
COD, mg/l	120	48	35	14	14
Suspended Solids, mg/l	250	25	3	3	3
Volatile Suspended Solids, mg/l	125	--	--	--	--
Phosphorous -P, mg/l	7	0.2	0.1	0.1	0.1
Ammonia -N, mg/l	7	7	7	7	0.5
Nitrites and Nitrates -N, mg/l	1	1	1	1	1
Oil and Grease, mg/l	30	24	2	1	1
Monroe County (1,400 mgd)					
BOD_5, mg/l	40	15	8	2	2
COD, mg/l	100	40	28	11	11
Suspended Solids, mg/l	300	30	3	3	3
Volatile Suspended Solids, mg/l	120	--	--	--	--
Phosphorous -P, mg/l	6.5	0.2	0.1	0.1	0.1
Ammonia -N, mg/l	4.5	4.5	4.5	4.5	0.5
Nitrites and Nitrates -N, mg/l	1	1	1	1	1
Oil and Grease, mg/l	25	20	2	1	1

could be constructed near the source of limestone as the regional auxiliary supply point.

Chlorine generation facilities could be constructed at several central locations to economically provide the large quantity of chlorine necessary, unless it is deemed preferable to purchase chlorine from a private source. Chlorine for the plants treating less than 100 mgd would be shipped by truck in ton cylinders. Larger plants would receive chlorine gas in railroad tank cars.

Large barge terminals for storage of methanol and ferric chloride on a regional basis are recommended. Delivery to each plant would be by truck or rail depending on consumption at each individual plant.

Power could be purchased from existing sources, but to increase system reliability, construction of several centrally located facilities to serve wastewater plants in the region should be considered. These plants would normally be used to operate the treatment facilities and emergency arrangements could then be made with existing power suppliers.

Resource Requirements

Land - Land is required for both wastewater treatment plant sites and for sludge disposal. The area required for plant sites depends upon the final plant layout which is influenced by the site topography and the size of tracts available at the selected locations. The total area required for each plant site has been estimated and is shown with the cost estimates, Tables 4 through 17. A land cost of $1,378 per acre was used for estimating the land requirements for new plants.

The area required for landfill alternatives is based on filling to a sludge depth of 12 feet. Land areas required are tabulated in Table 3. For purposes of estimating the landfill area required, the average design flow has been considered to remain constant for the 50-year design period.

Power - Estimated power demands for the proposed wastewater treatment system are shown in Table 25.

Chemicals - Estimated chemical requirements for each proposed wastewater treatment plant are presented in Table 26. Large quantities of lime and chlorine will be required in all of the proposed treatment plants; substantial volumes of methanol will also be required in the municipal and industrial wastewater treatment plants. Chemical conditioning of the primary and waste biological sludge at the five largest municipal and industrial wastewater treatment plants will require a great deal of lime and ferric chloride. It may be possible to substitute polymer for the lime and ferric chloride for sludge conditioning, but this would have to be determined by pilot scale tests at each plant. It may also be feasible to mix lime sludge with the primary and waste biological sludge to increase the dewatering characteristics with reduced consumption of lime and ferric chloride. This would also have to be evaluated by more detailed investigations.

Labor - Estimates of labor of various skill levels required to operate and maintain the proposed wastewater treatment plants in the study area are presented in Tables 27 and 28.

The estimated work force required at the municipal and industrial wastewater treatment plants is considered adequate to operate the plants at the design flows. Since all of the proposed plants, except Detroit, will initially be operating at somewhat lower flow rates, a smaller initial work force will be adequate at those locations.

In arriving at the work force required to operate and maintain the stormwater treatment plants, the assumption was made that enough personnel would be employed to operate the plants at 50 percent of the maximum design capacity. During years of average rainfall, a little overtime employment will be required to operate the plants during the two wettest months. During years of extremely heavy precipitation, permanent employees would be required to work overtime and additional unskilled employees would have to be added to the work force on a temporary basis.

TABLE 25

ESTIMATED POWER DEMAND

Municipal and Industrial Wastewater Treatment Plants

	Power Demand Kilowatts
Adrian (12 mgd)	2,400
Port Huron (24 mgd)	4,600
Monroe (40 mgd)	7,400
Wayne County (125 mgd)	22,000
Mouth of Huron River (400 mgd)	66,800
Mouth of Huron River (525 mgd)	86,600
Detroit (806 mgd)	131,000

Stormwater Treatment Plants

	Power Demand At Maximum Flow Kilowatts	Power Demand at Yearly Average Flow Kilowatts
East China (125 mgd)	7,000	2,200
Plymouth or Ypsilanti (225 mgd)	12,000	3,800
Macomb County (400 mgd)	20,500	6,500
Conner Creek (600 mgd)	30,000	9,400
Monroe County (1,000 mgd)	48,000	15,200
Conner Creek (1,200 mgd)	56,600	18,100
Monroe County (1,400 mgd)	65,800	20,800

TABLE 26

ESTIMATED CHEMICAL REQUIREMENTS

Municipal and Industrial Wastewater Treatment Plants

	Wastewater Treatment						Sludge Conditioning	
	Lime		Methanol		Chlorine		Lime	Ferric Chloride
	lbs/mg	ton/day	lbs/mg	ton/day	lbs/mg	ton/day	ton/day	ton/day
Adrian (12 mgd)	1,668	10.0	350	2.1	21	.13	--	--
Port Huron (24 mgd)	1,668	20.0	292	3.5	21	.25	--	--
Monroe (40 mgd)	1,668	33.4	200	4.0	21	.42	2.8	0.83
Wayne County (125 mgd)	1,418	88.5	292	18.3	21	1.30	9.6	2.88
Mouth of Huron River (400 mgd)	1,418	283	292	58.4	21	4.17	30.8	9.25
Mouth of Huron River (525 mgd)	1,418	372	292	76.7	21	5.47	40.4	12.1
Detroit (806 mgd)	1,418	571	292	117.7	21	8.40	62.0	18.6

Stormwater Treatment Plants

	Lime			Chlorine		
	lbs/mg	ton/day at maximum flow	ton/day at yearly average flow	lbs/mg	ton/day at maximum flow	ton/day at yearly average flow
East China (125 mgd)	1,668	104	30	250	16	4.6
Plymouth or Ypsilanti (225 mgd)	1,418	160	46	250	28	8.1
Macomb County (400 mgd)	1,418	284	82	250	50	14.5
Conner Creek (600 mgd)	1,418	425	123	584	175	51
Monroe County (1,000 mgd)	1,418	708	205	584	292	85
Conner Creek (1,200 mgd)	1,418	851	247	584	350	102
Monroe County (1,400 mgd)	1,418	992	288	375	263	76

TABLE 27

ESTIMATED WORK FORCE REQUIRED TO OPERATE AND MAINTAIN
THE MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANTS

	Adrian	Port Huron	Monroe	Wayne County	Mouth of Huron River	Mouth of Huron River	Detroit
Average Flow, mgd	12	24	40	125	400	525	806
Superintendent	1	1	1	1	1	1	1
Assistant Superintendent	--	1	1	1	1	1	1
Clerk Typist	1	1	2	3	7	9	14
Operations Supervisor	--	1	2	3	7	9	12
Shift Foreman	--	3	6	15	42	55	80
Operator II	10	16	22	48	150	200	304
Operator I	15	24	28	65	200	260	400
Maintenance Supervisor	--	1	1	3	6	6	9
Mechanical Maintenance Foreman	--	1	3	9	26	33	48
Maintenance Mechanic II	2	4	5	9	27	35	48
Maintenance Mechanic I	2	3	4	5	16	21	32
Electrician II	1	2	2	5	16	21	32
Electrician I	--	1	2	5	16	21	32
Laborer	7	14	20	50	150	200	300
Truck Driver	1	3	2	2	15	20	38
Chemist	--	--	1	2	3	4	5
Laboratory Technician	4	5	6	8	24	30	46
Total	44	81	108	234	707	926	1,402

TABLE 28

ESTIMATED WORK FORCE REQUIRED TO OPERATE AND MAINTAIN*

THE STORMWATER TREATMENT PLANTS

	East China	Plymouth or Ypsilanti	Macomb County	Conner Creek	Monroe County	Conner Creek	Monroe County
Maximum Capacity, mgd	125	225	400	600	1,000	1,200	1,400
Superintendent	1	1	1	1	1	1	1
Assistant Superintendent	1	1	1	1	1	1	1
Clerk Typist	3	4	5	6	8	9	10
Operations Supervisor	1	1	2	2	3	3	3
Shift Foreman	4	6	10	15	25	30	35
Operator II	17	24	37	55	91	114	134
Operator I	20	27	40	60	100	120	140
Maintenance Supervisor	1	1	2	2	3	3	3
Mechanical Maintenance Foreman	3	4	6	9	15	18	21
Maintenance Mechanic II	3	5	7	11	18	22	26
Maintenance Mechanic I	2	4	5	8	13	16	19
Electrician II	2	4	5	6	10	12	14
Electrician I	2	3	4	6	10	12	14
Laborer	20	27	40	60	100	120	140
Truck Driver	2	1	1	2	2	3	3
Chemist	1	1	2	2	3	4	4
Laboratory Technician	3	4	6	9	15	18	21
Total	86	118	174	255	418	506	589

* The assumption was made that enough personnel would be employed to operate the stormwater treatment plants at 50 percent of maximum capacity.

Fuel - An outside fuel source will be required for thermal conditioning, incineration, recalcination, and heating of plant buildings. Either natural gas or fuel oil is acceptable and can be used subject to availability. Quantities of natural gas or fuel oil required at the various treatment plants are presented in Table 29. Also presented in Table 29 are the quantities of diesel fuel required for trucks hauling sludge and ash to landfill disposal.

Time Phasing

The proposed municipal and industrial treatment plants have been designed to treat specified 1990 wastewater flows. The plants are expected to have a useful life of at least fifty years. If the population and resulting water usage continues to increase in the study area beyond the 1990 levels, additions to each plant will be required to increase capacity.

The proposed stormwater treatment plants are designed to treat storm runoff from areas which are expected to develop by 1990. These plants are also anticipated to have a useful life of at least fifty years. Plant additions or construction of additional plants will be required as a result of development patterns evolving in the post-1990 period.

The Detroit and Port Huron wastewater treatment plants have existing incinerators with adequate capacity to burn all of the sludge generated at Port Huron and about 80 percent of the sludge expected from Detroit. The cost analysis of the various sludge disposal methods at these two plants showed hauling dewatered sludge to a landfill to be more economical than incineration considering the need to maintain high temperatures for odor control and scrubbers for particulate removal. It is recommended that incineration be utilized only throughout the life of existing equipment, or until environmental factors point toward the need for substantial capital investments for improved air pollution control.

TABLE 29

ESTIMATED FUEL REQUIREMENTS

	Natural Gas(1) Millions of ft^3/year	Fuel Oil(1) Millions of gallons/year	Diesel Fuel(2) Thousands of gallons/year
Municipal and Industrial Wastewater Treatment Plants			
Adrian (12 mgd)	32	0.22	14.4
Port Huron (24 mgd)	45	0.32	26.1
Monroe (40 mgd)	421	3.01	26.0
Wayne County (125 mgd)	1,048	7.48	46.3
Mouth of Huron River (400 mgd)	1,774	12.63	347.2
Mouth of Huron River (525 mgd)	2,227	15.87	458.6
Detroit (806 mgd)	2,953	22.10	939.2
Stormwater Treatment Plants			
East China (125 mgd)	25	0.17	40.0
Plymouth or Ypsilanti (225 mgd)	356	2.54	5.2
Macomb County (400 mgd)	543	3.88	9.6
Conner Creek (600 mgd)	743	5.30	24.4
Monroe County (1,000 mgd)	1,121	8.01	20.8
Conner Creek (1,200 mgd)	1,215	8.68	49.6
Monroe County (1,400 mgd)	1,344	9.59	30.4

(1) Either natural gas or fuel oil can be used for thermal conditioning, incineration, recalcination and plant heating.

(2) Diesel fuel to be used for hauling sludge and incinerator ash to landfill disposal.

SECTION IV - SUMMARY

This report summarizes investigations, evaluations, and recommended systems for municipal-industrial wastewater and stormwater treatment in the southeast Michigan metropolitan area.

Flow volumes and water quality profiles have been provided for seven municipal-industrial and seven stormwater treatment plants. Based upon this information and preliminary submittals to the Detroit District, recommended treatment arrangements have been developed for each site.

The general sequence of treatment operations recommended for the municipal-industrial plants includes raw waste pumping, preliminary treatment, primary treatment, activated sludge secondary treatment, biological nitrification, two-stage lime clarification, multi-media filtration (with denitrification), carbon adsorption, and chlorination. Sludge handling arrangements vary somewhat depending upon existing facilities at each plant. In general, however, thickened, conditioned sludge is dewatered on vacuum filters and hauled to landfills for disposal.

Stormwater treatment plants have been designed assuming primary treatment will be provided at the site of the flow equalization storage facilities. Treatment units recommended herein include two-stage lime clarification with recalcination of the lime sludge, multi-media filtration, and two-stage carbon adsorption with breakpoint chlorination for ammonia removal between the two stages. Sludge disposal recommendations are generally for landfill disposal of dewatered sludge and waste recalcination ash.

Cost estimates have been developed for the recommended plant arrangements. System reliability and performance, opportunities for multiple use of facilities, and resource requirements for construction and operation of recommended plant components are included herein.

Respectfully submitted,

STANLEY CONSULTANTS

By Bennett D. Reischauer
Bennett D. Reischauer

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L. G. Koehrsen, P.E.

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ADVANCED WASTEWATER TREATMENT FACILITIES FOR SOUTHEASTERN MICHI--ETC(U)

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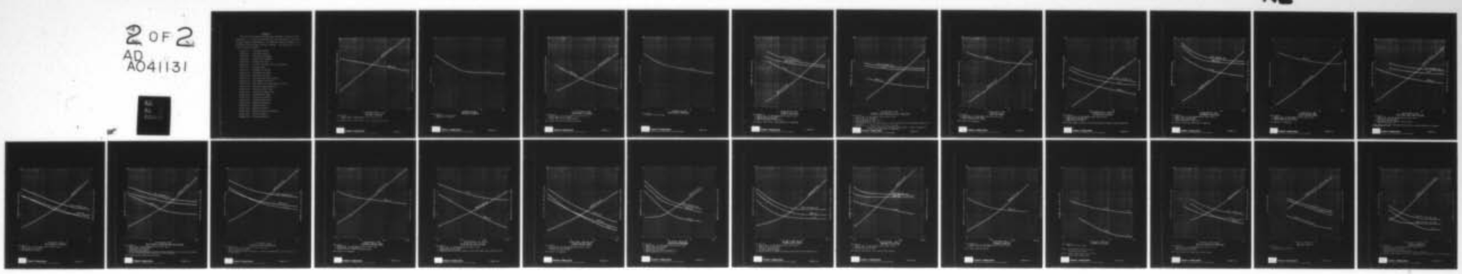

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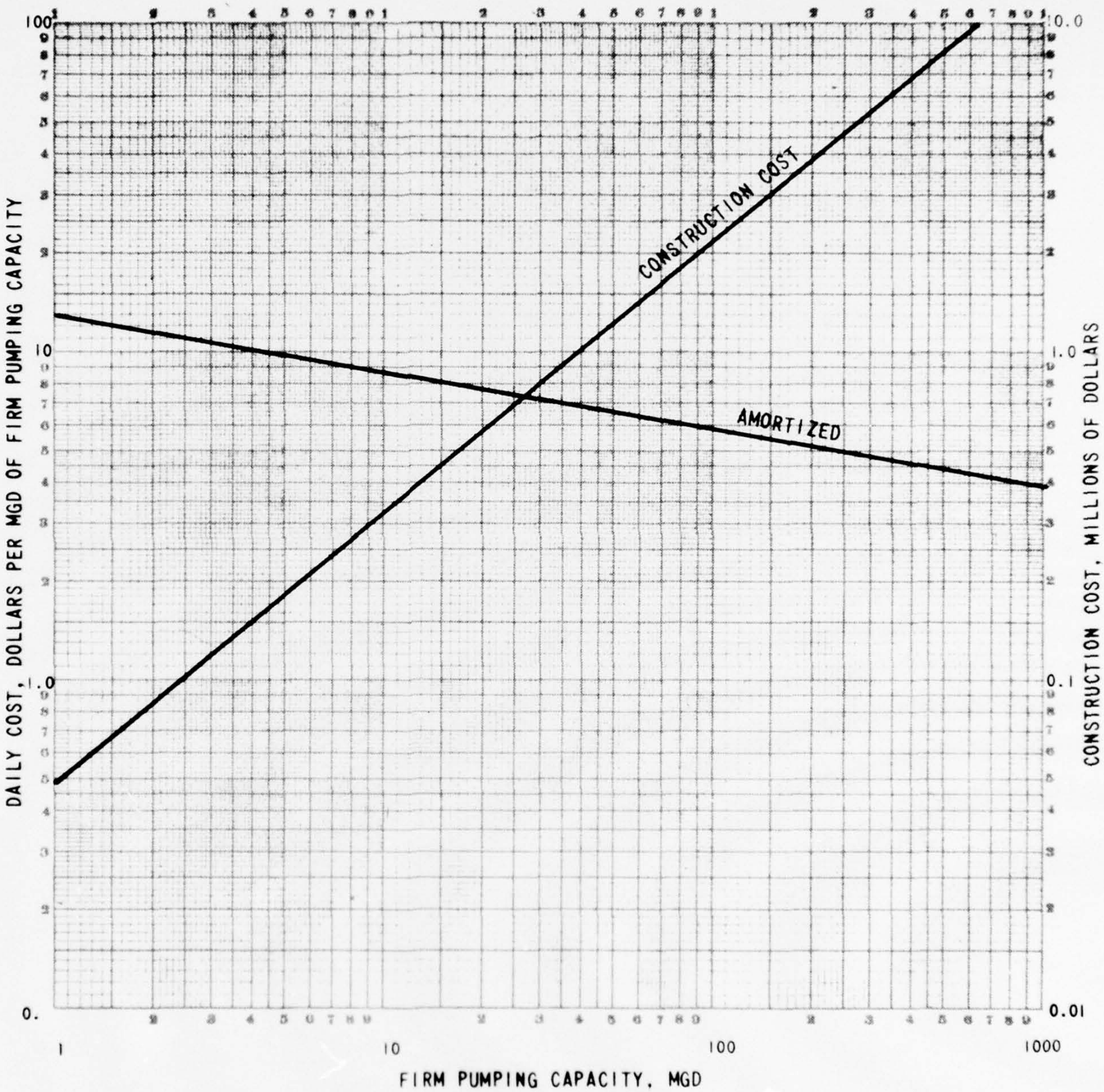
APPENDIX A

The cost curves presented herein were developed utilizing Stanley Consultants, Inc. internal treatment plant cost information, costs from various equipment manufacturers, Environmental Protection Agency cost information and cost data from the literature. The following is a list of the figures presented:



RAW WASTE PUMPING

COSTS BASED ON:
1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.

COSTS INCLUDE: VALVES, CONTROLS, WET WELL, DRY WELL AND ENCLOSING STRUCTURE.

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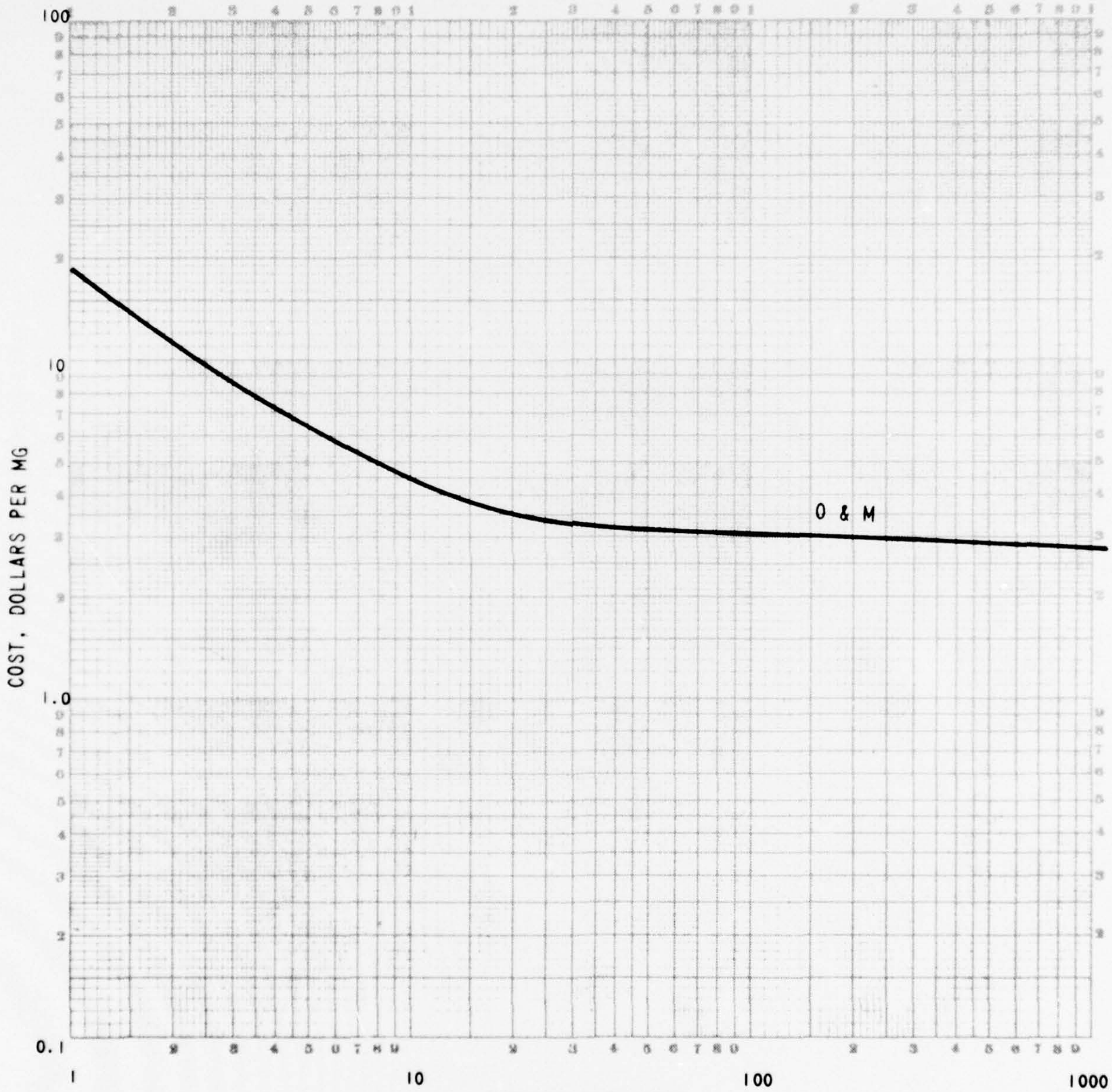
FIGURE A-1



RAW WASTE PUMPING

COSTS BASED ON:
1. LABOR RATE OF $6.00 PER HOUR.
2. POWER COST OF 1¢ PER KWH.

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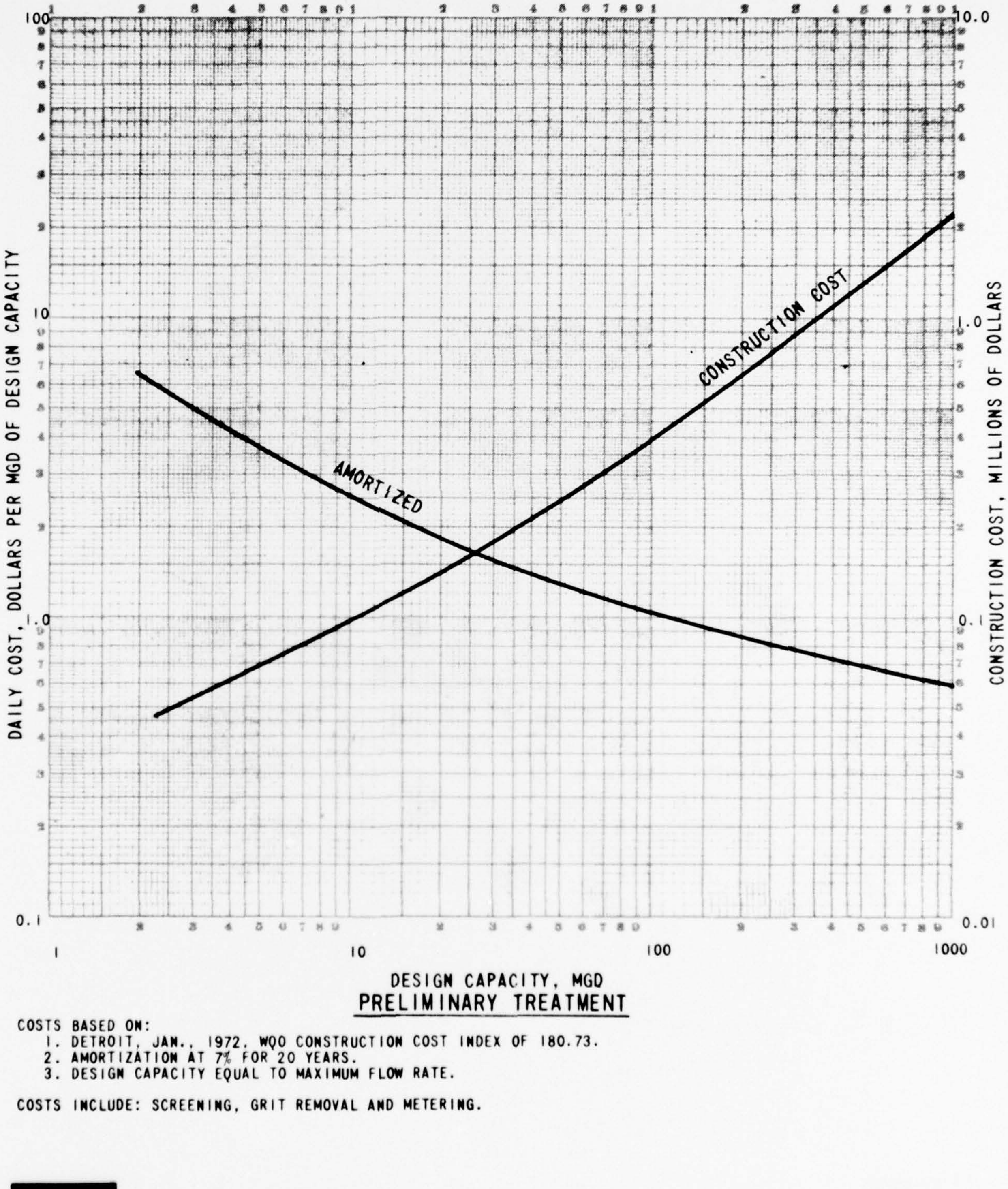
FIGURE A-2



PRELIMINARY TREATMENT

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. DESIGN CAPACITY EQUAL TO MAXIMUM FLOW RATE.

COSTS INCLUDE: SCREENING, GRIT REMOVAL AND METERING.

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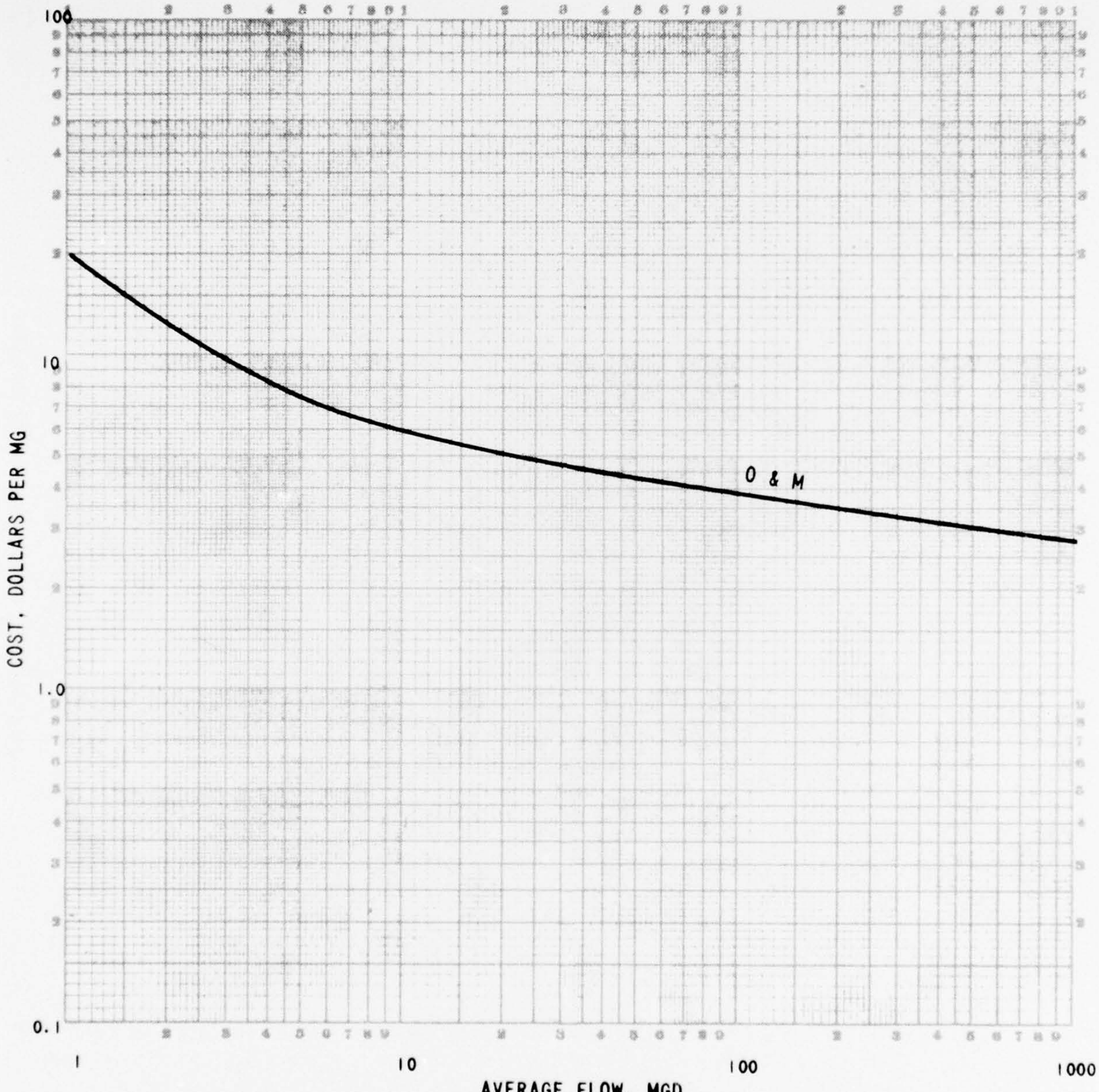
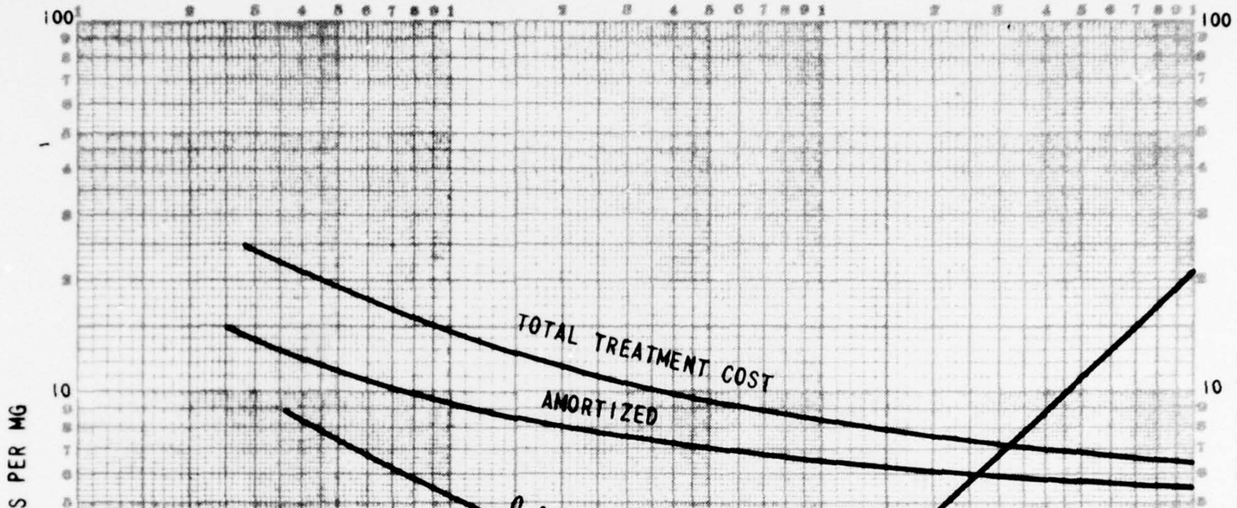
FIGURE A-3



PRELIMINARY TREATMENT

COSTS BASED ON:
1. LABOR RATE OF $6.00 PER HOUR.



DESIGN CAPACITY, MGD

PRIMARY CLARIFIERS

COSTS BASED ON:
1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. SURFACE OVERFLOW RATE OF 1000 GPD/FT^2.

COSTS INCLUDE: FLOW SPLITTERS, SLUDGE PUMPING AND PILE FOUNDATIONS.

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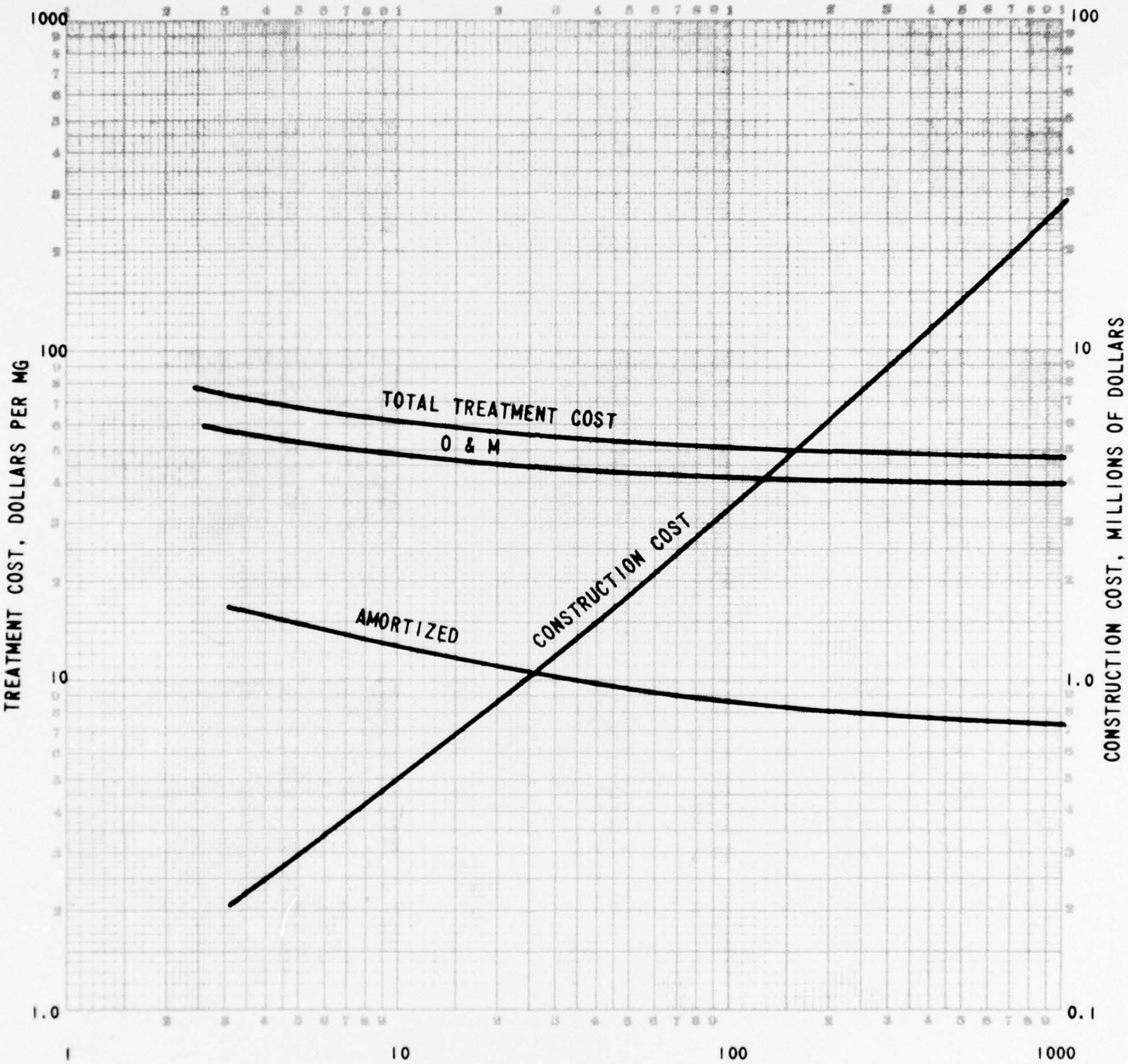
FIGURE A-5



PRIMARY CLARIFIERS WITH Fe Cl_3 ADDITION

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. SURFACE OVERFLOW RATE OF 1000 GPD/FT^2.
5. PHOSPHOROUS REMOVAL OF 80%.
6. Fe Cl_3 DOSAGE OF 80 mg/l AND POLYMER DOSAGE OF 0.5 mg/l FOR AN AVERAGE INFLUENT PHOSPHOROUS CONCENTRATION OF 10^3 mg/l.
7. CHEMICAL COSTS: Fe Cl_3=$80 PER TON, POLYMER = $1.50 PER POUND.

COSTS INCLUDE: FLOW SPLITTERS, MIXING AND FLOCCULATION UNITS, CHEMICAL STORAGE AND FEED EQUIPMENT, SLUDGE PUMPING AND PILE FOUNDATIONS.

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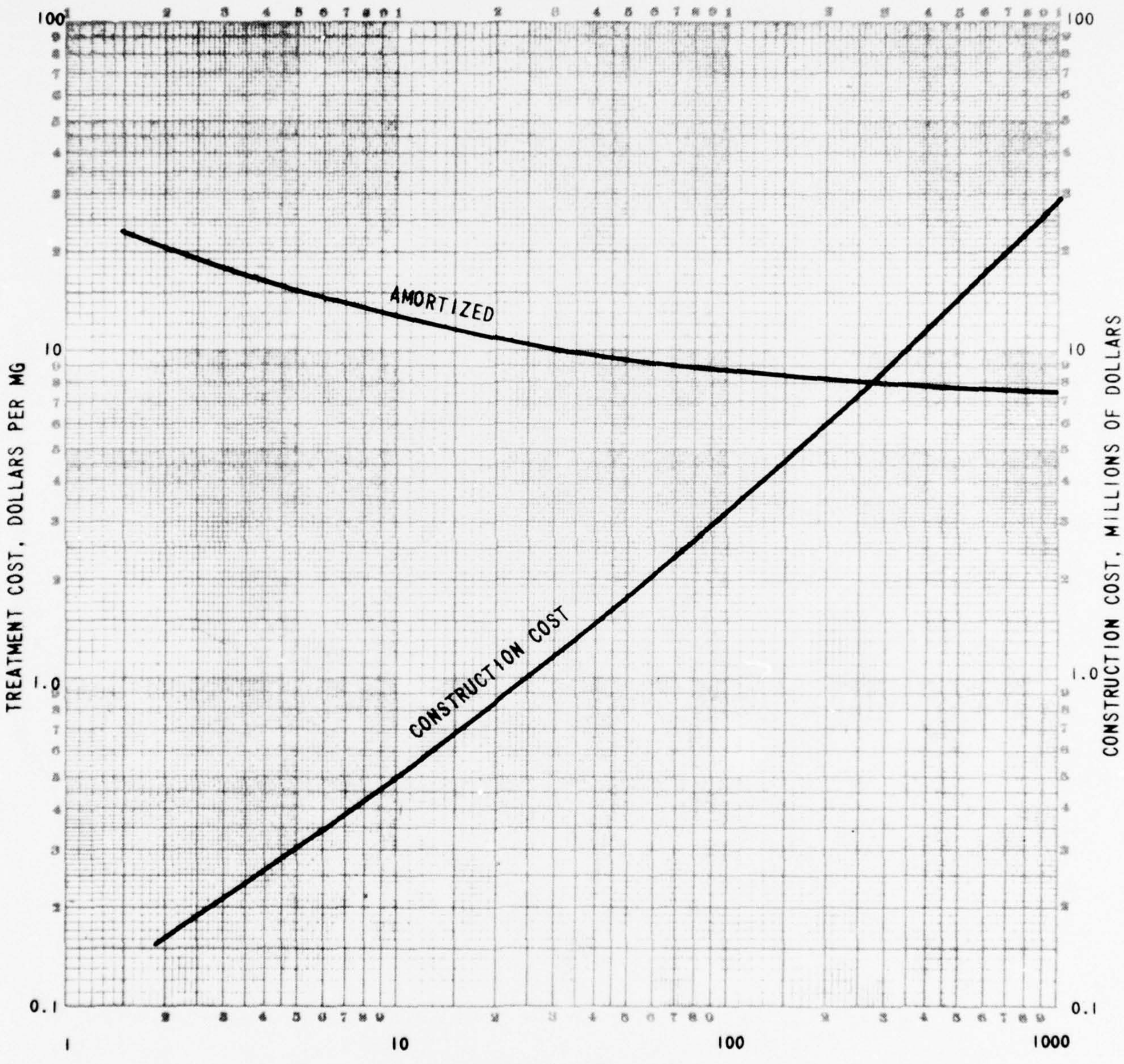
FIGURE A-6



AERATION TANKS

COSTS BASED ON:
1. DETROIT, JAN., 1972. WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. AVERAGE DETENTION TIME OF 4 HOURS.

COSTS INCLUDE: PILE FOUNDATIONS.

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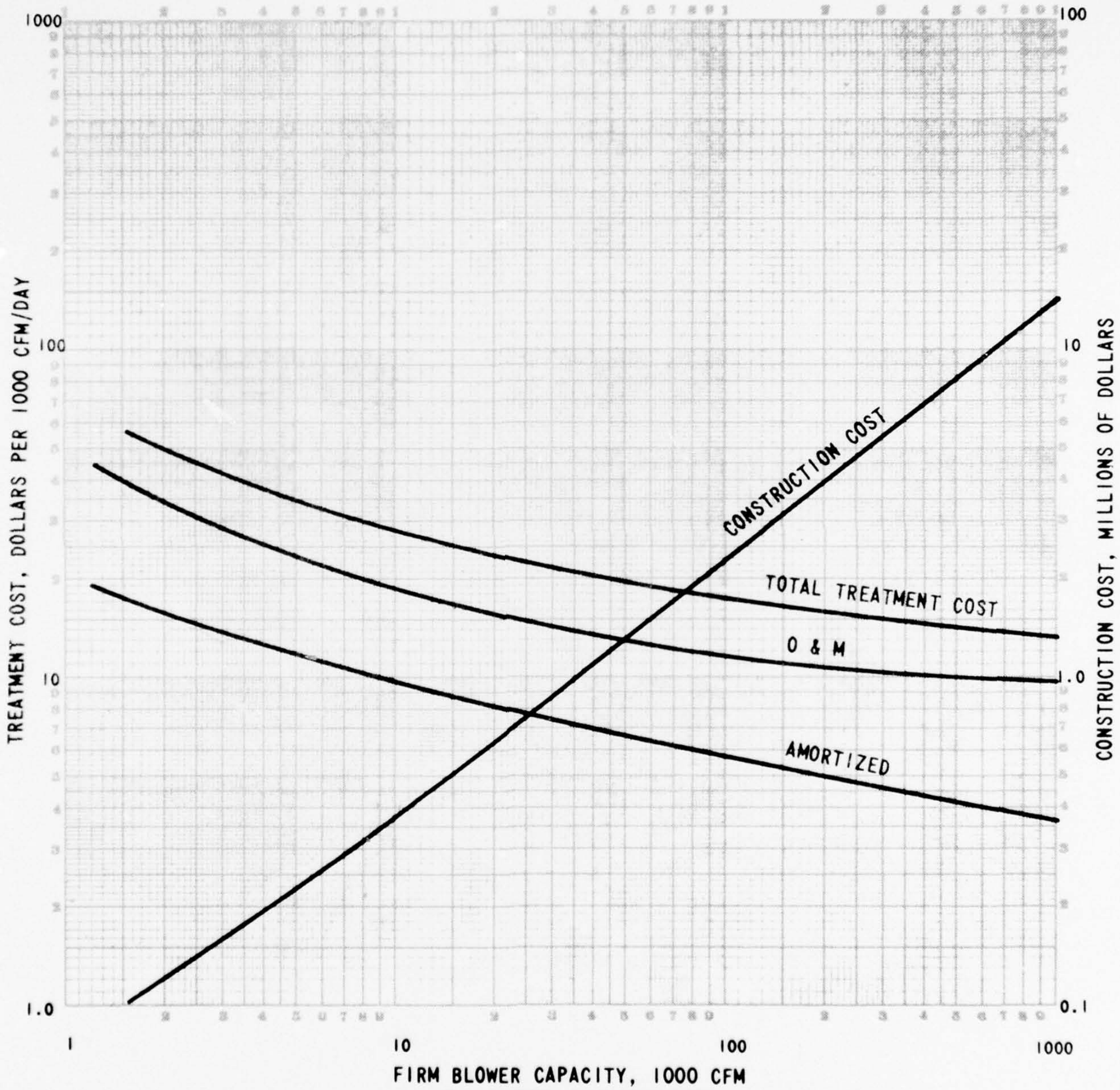
FIGURE A-7

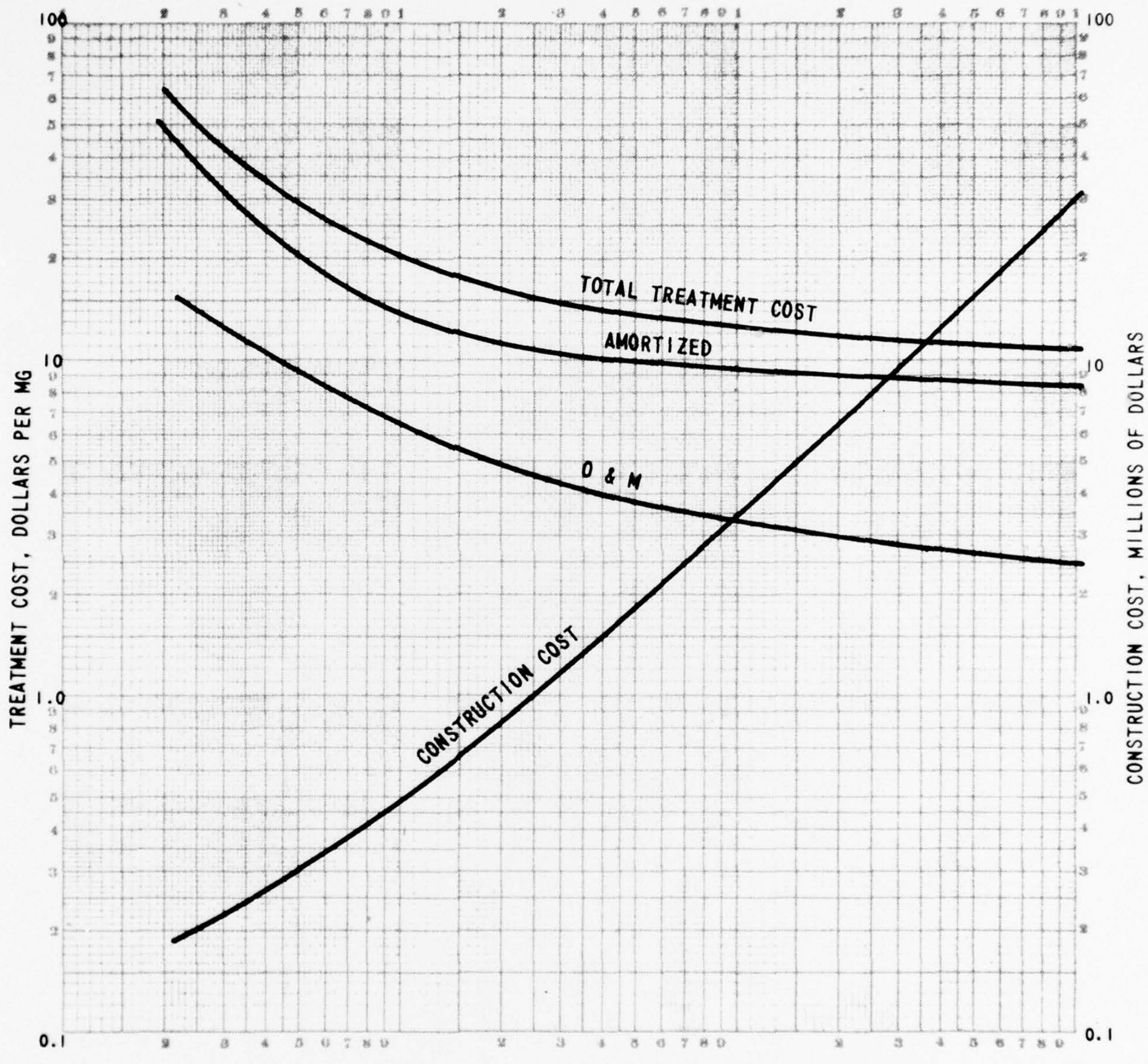


DIFFUSED AIR SYSTEM

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. POWER COST OF 1¢ PER KWH.

COSTS INCLUDE: BLOWERS, DIFFUSERS, AIR PIPING AND ACCESSORIES, BLOWER BUILDING AND FOUNDATIONS.



SECONDARY CLARIFIERS

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. SURFACE OVERFLOW RATE OF 800 GPD/FT^2.

COSTS INCLUDE: RETURN SLUDGE PUMPING AND PILE FOUNDATIONS.

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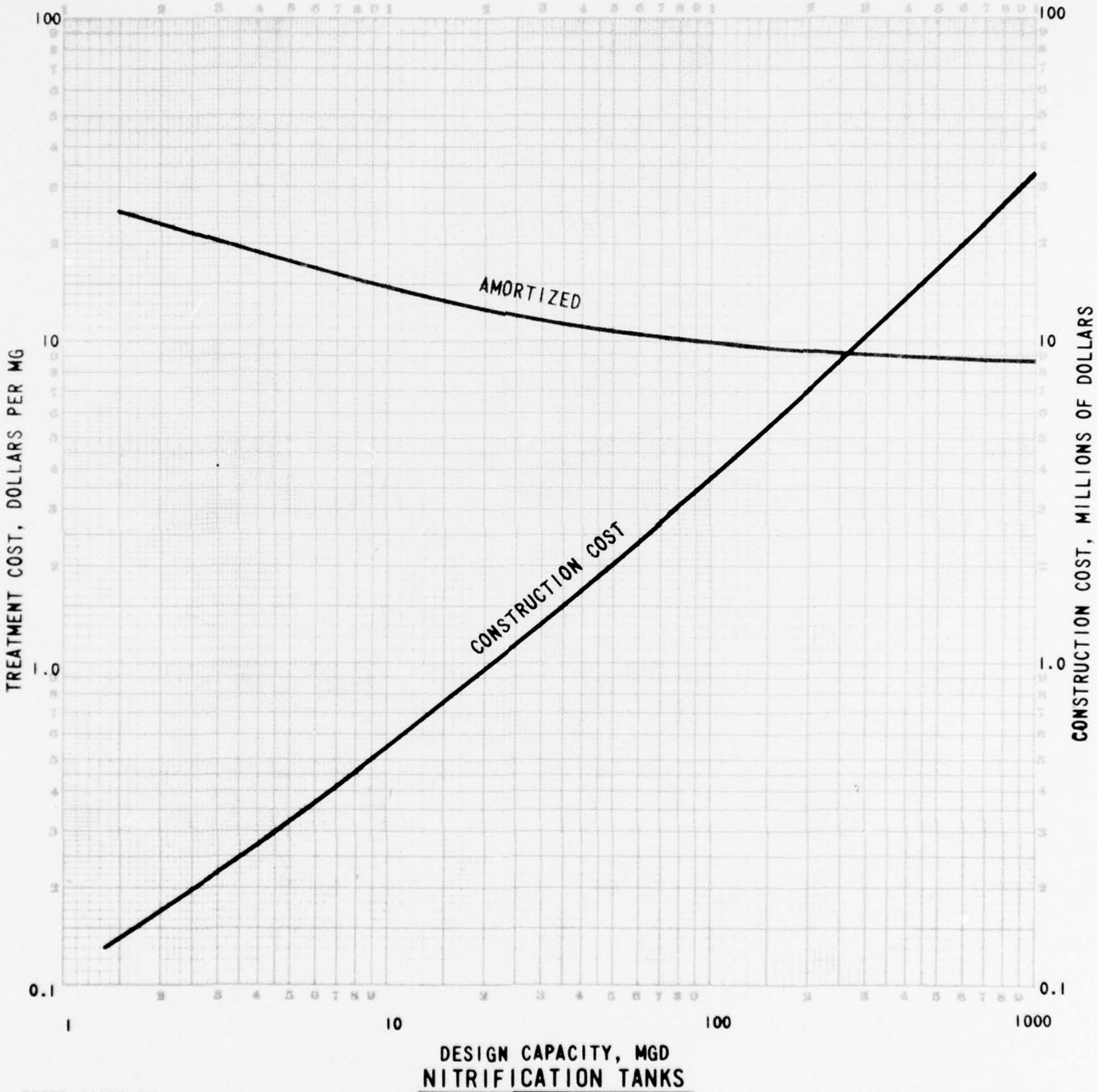
FIGURE A-9



NITRIFICATION TANKS

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. AVERAGE DETENTION TIME OF 5 HOURS.

COSTS INCLUDE: PILE FOUNDATIONS.

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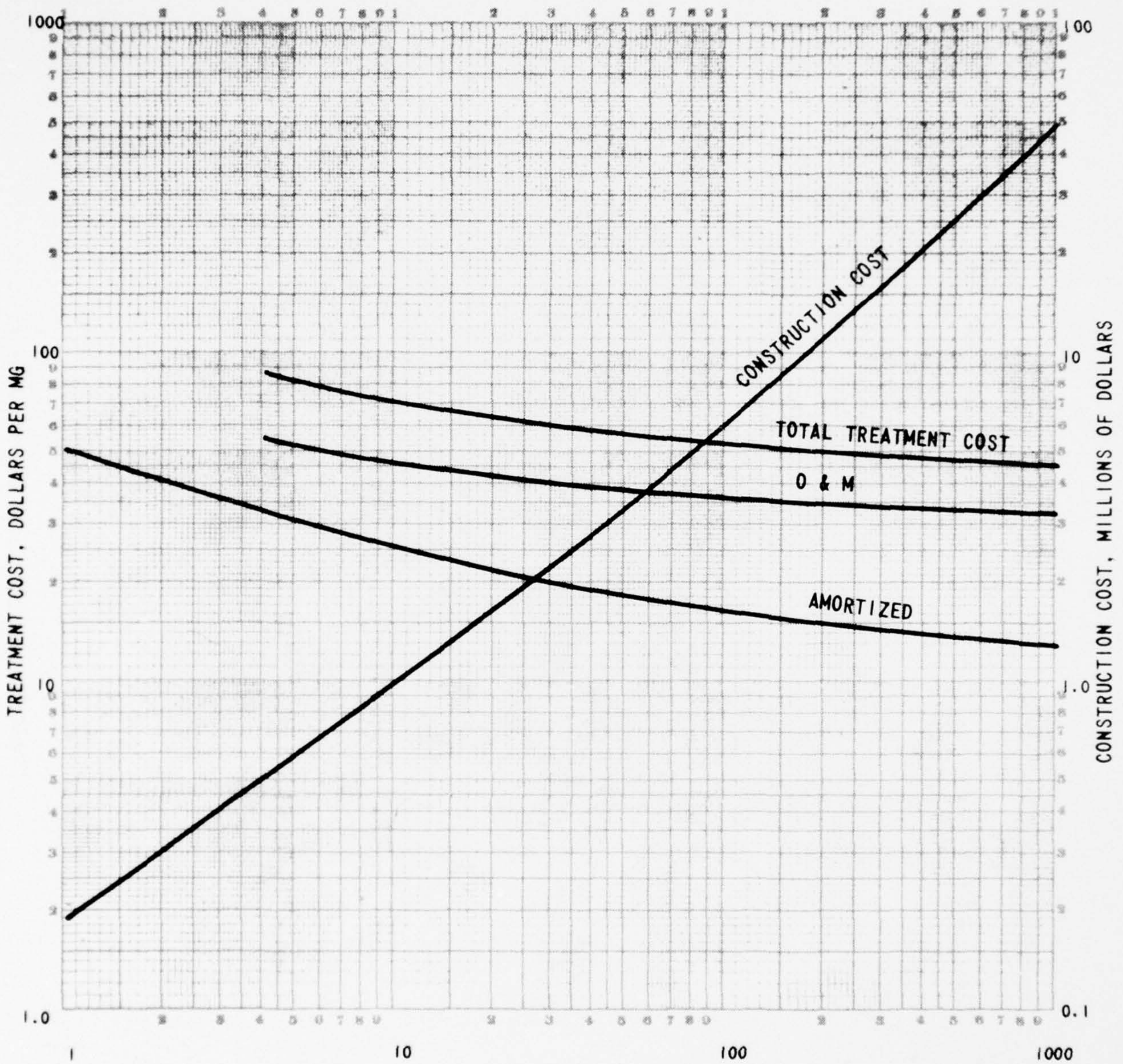
FIGURE A-10



TWO STAGE LIME CLARIFICATION

COSTS BASED ON:
1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. LIME DOSAGE = 200 mg/l, LIME COST = $18.50 PER TON.
5. NO RECALCINATION FACILITIES.

COSTS INCLUDE: TWO MIXING, FLOCCULATION AND CLARIFIER UNITS, CHEMICAL STORAGE AND FEED EQUIPMENT, RECARBONATION FACILITIES.

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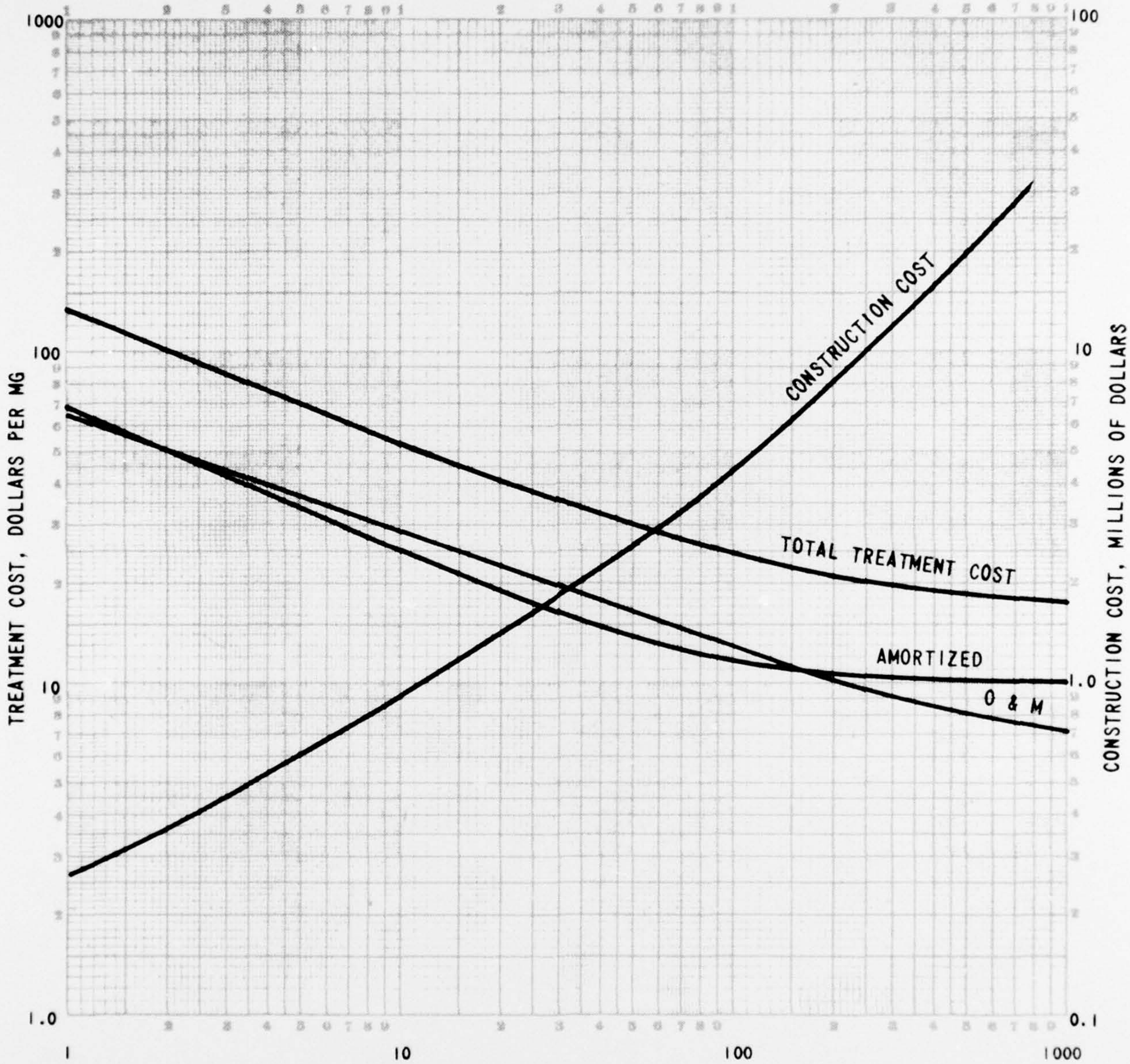
FIGURE A-11



MULTI-MEDIA FILTRATION

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. FILTRATION RATE OF 4 GPM/FT2.

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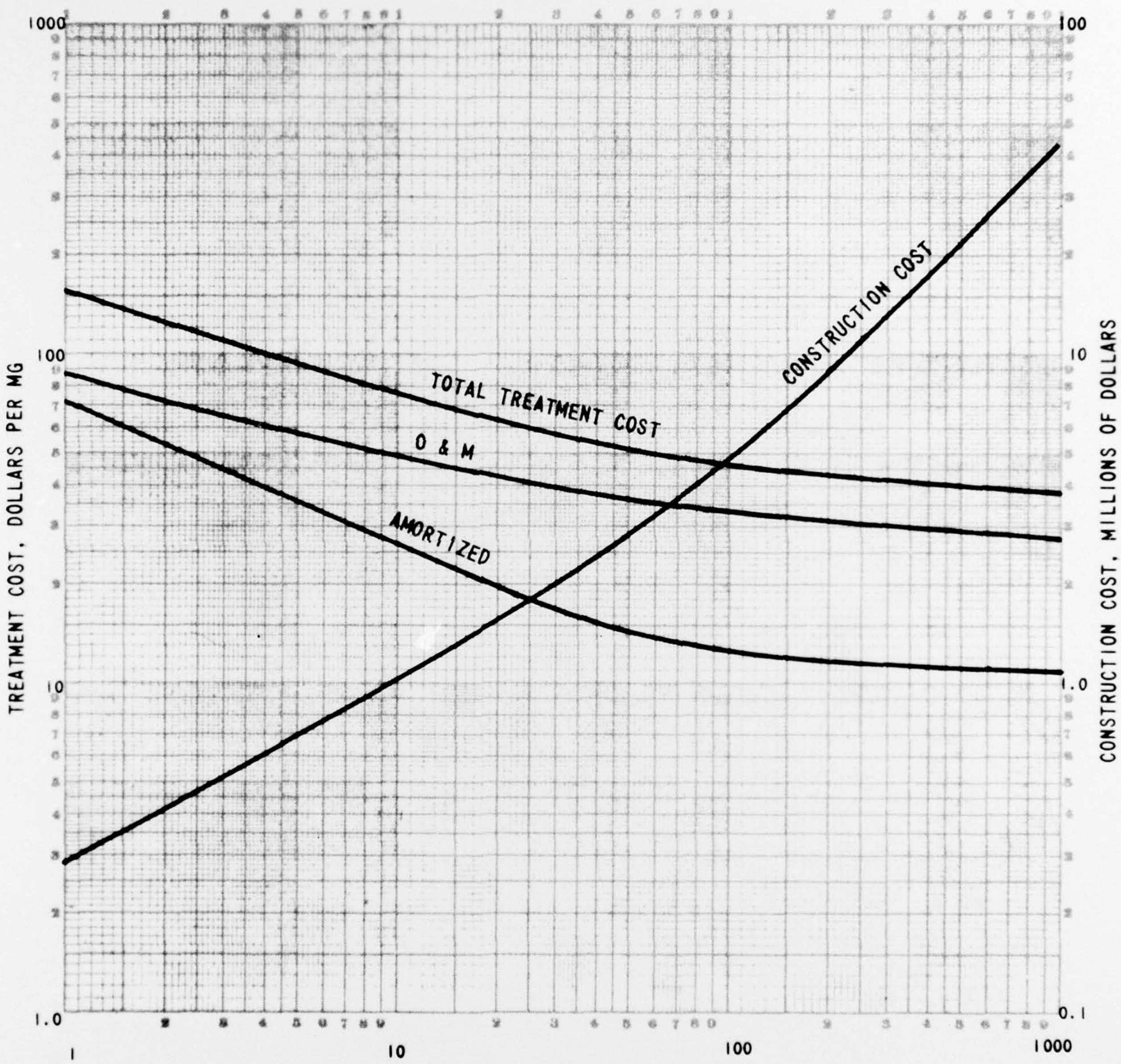
FIGURE A-12



MULTI-MEDIA FILTRATION-DENITRIFICATION

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. FILTRATION RATE OF 4 GPM/FT2.
5. OPERATION AND MAINTENANCE COSTS OF METHANOL ADDITION FOR REMOVING 20 mg/l OF NO_3-N IN THE PRESENCE OF 5 mg/l OF DISSOLVED OXYGEN ESTIMATED AT $20 PER MILLION GALLONS.

COSTS INCLUDE: METHANOL STORAGE AND FEED EQUIPMENT.

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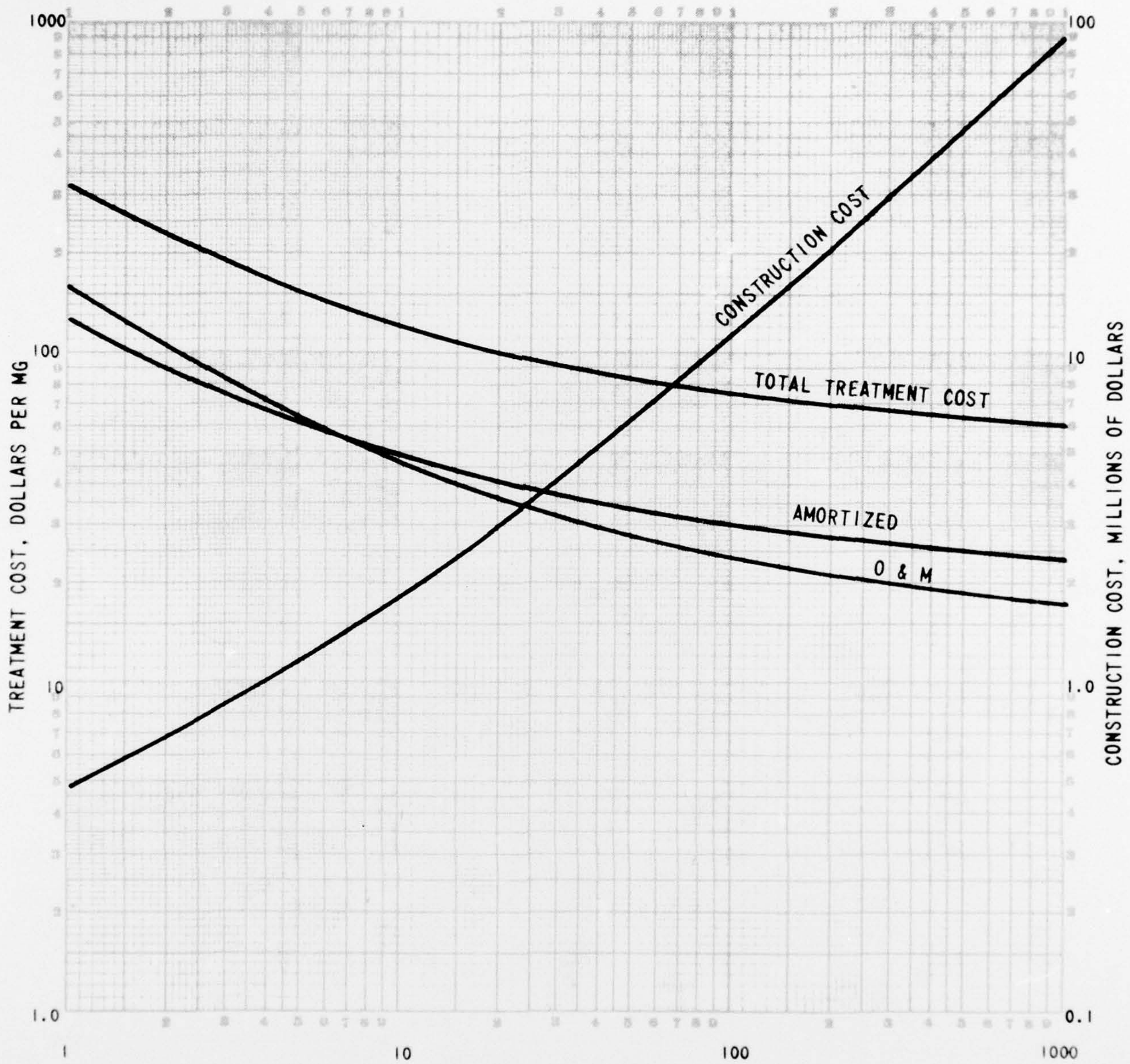
FIGURE A-13



GRANULAR CARBON ADSORPTION

COSTS BASED ON:
1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. AVERAGE CARBON CONTACT TIME OF APPROXIMATELY 15 MINUTES AND CARBON DOSAGE OF 250 TO 300 POUNDS PER MILLION GALLONS.

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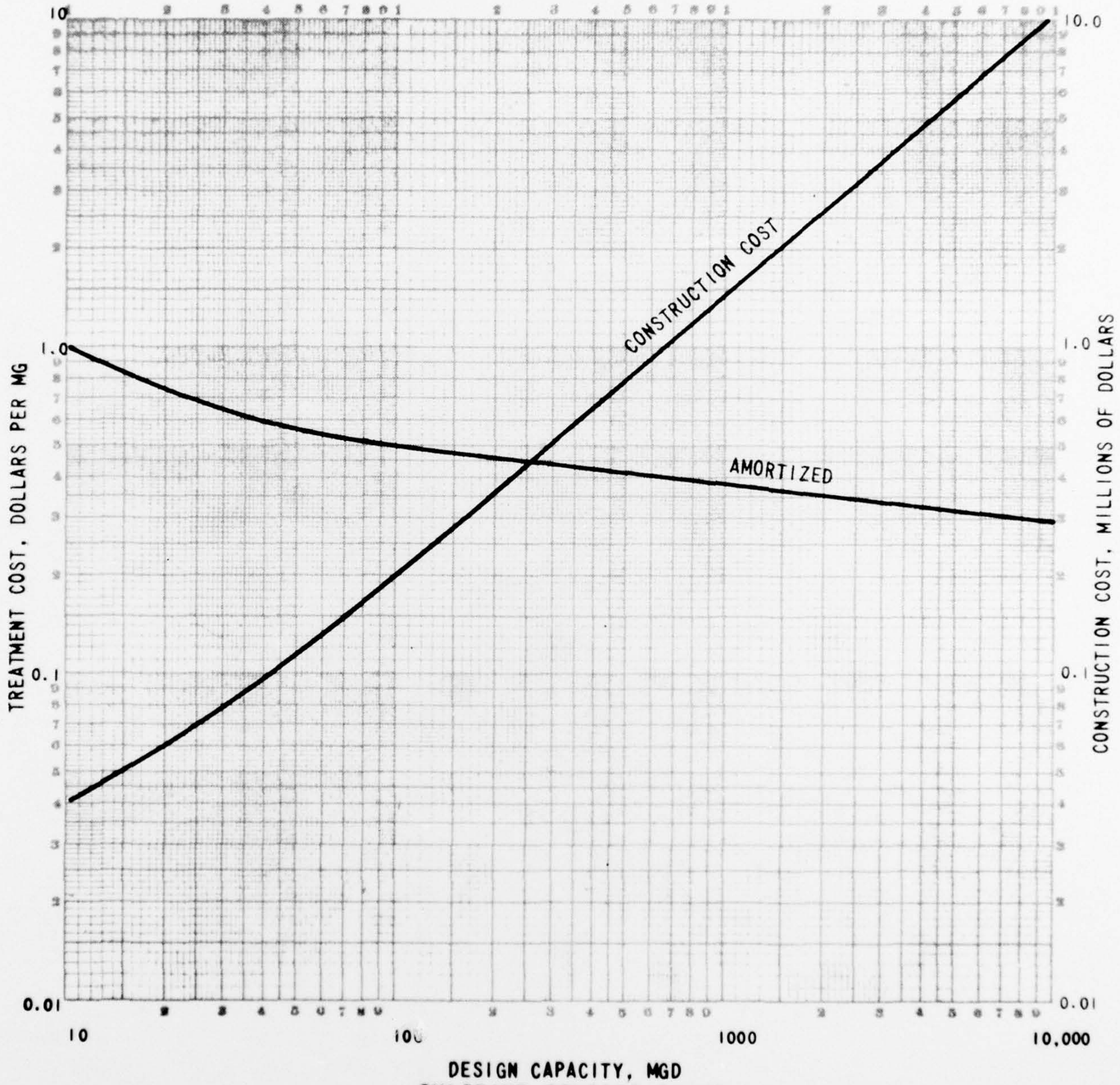
FIGURE A-14

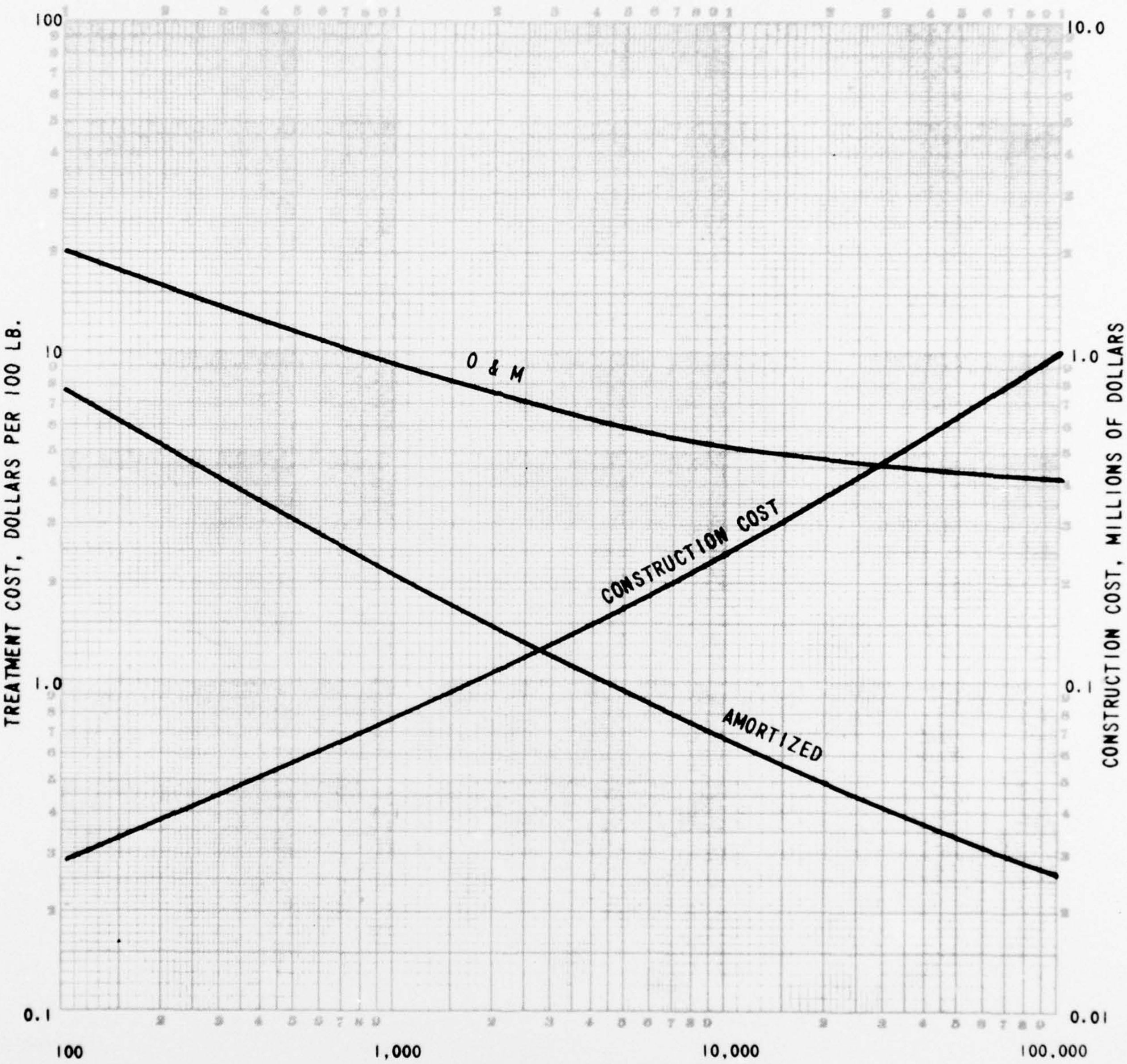


CHLORINE CONTACT TANKS

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. DETENTION TIME OF 15 MINUTES AT MAXIMUM FLOW RATE.

COSTS INCLUDE: PILE FOUNDATION.



CHLORINATION FEED SYSTEMS

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. MINIMUM CHLORINE COST OF 3.6¢ PER POUND AT CHLORINE USAGE GREATER THAN 1,000 TONS PER YEAR.

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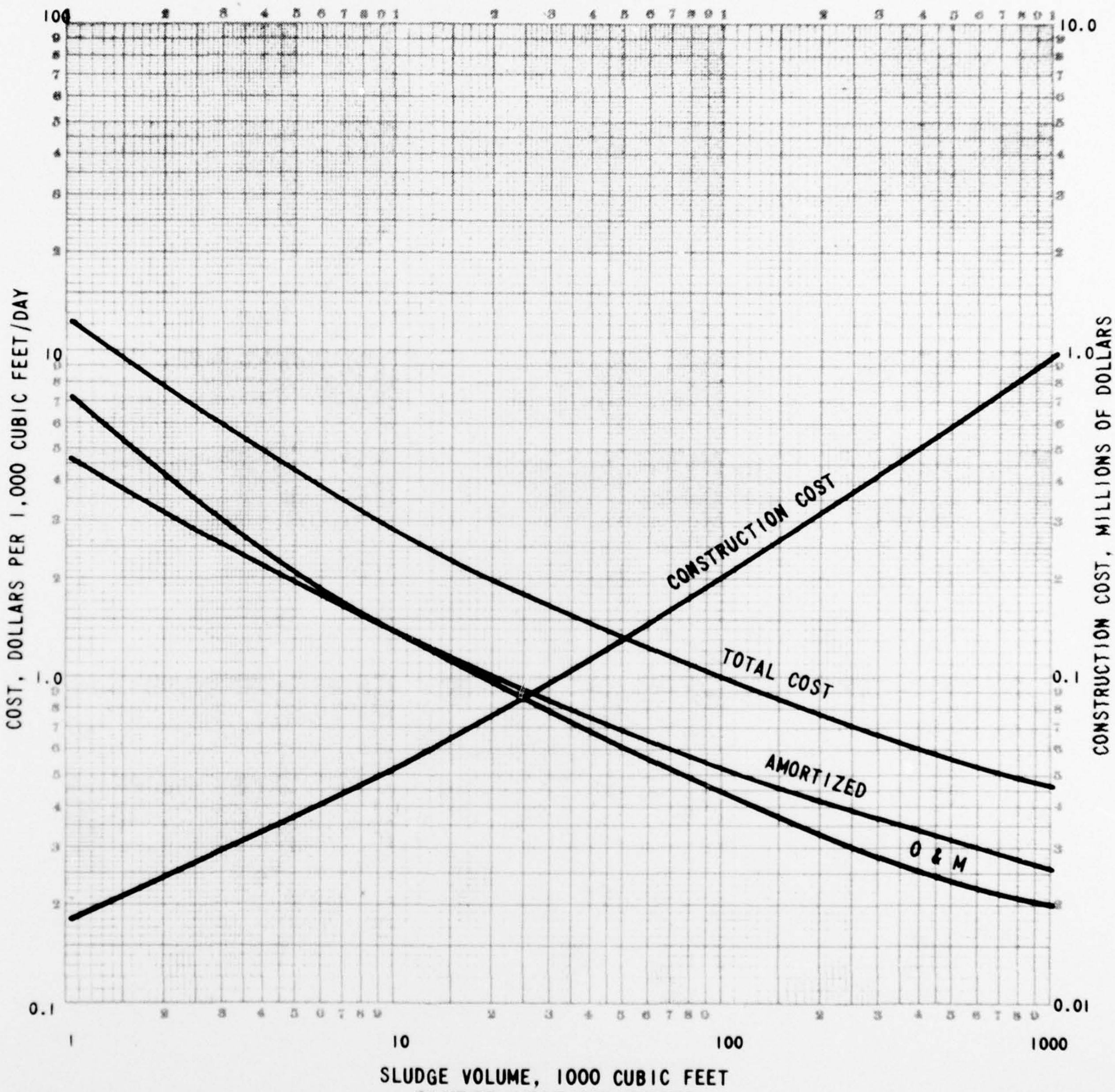
FIGURE A-16



SLUDGE HOLDING TANKS

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.

COSTS INCLUDE: PILE FOUNDATION.

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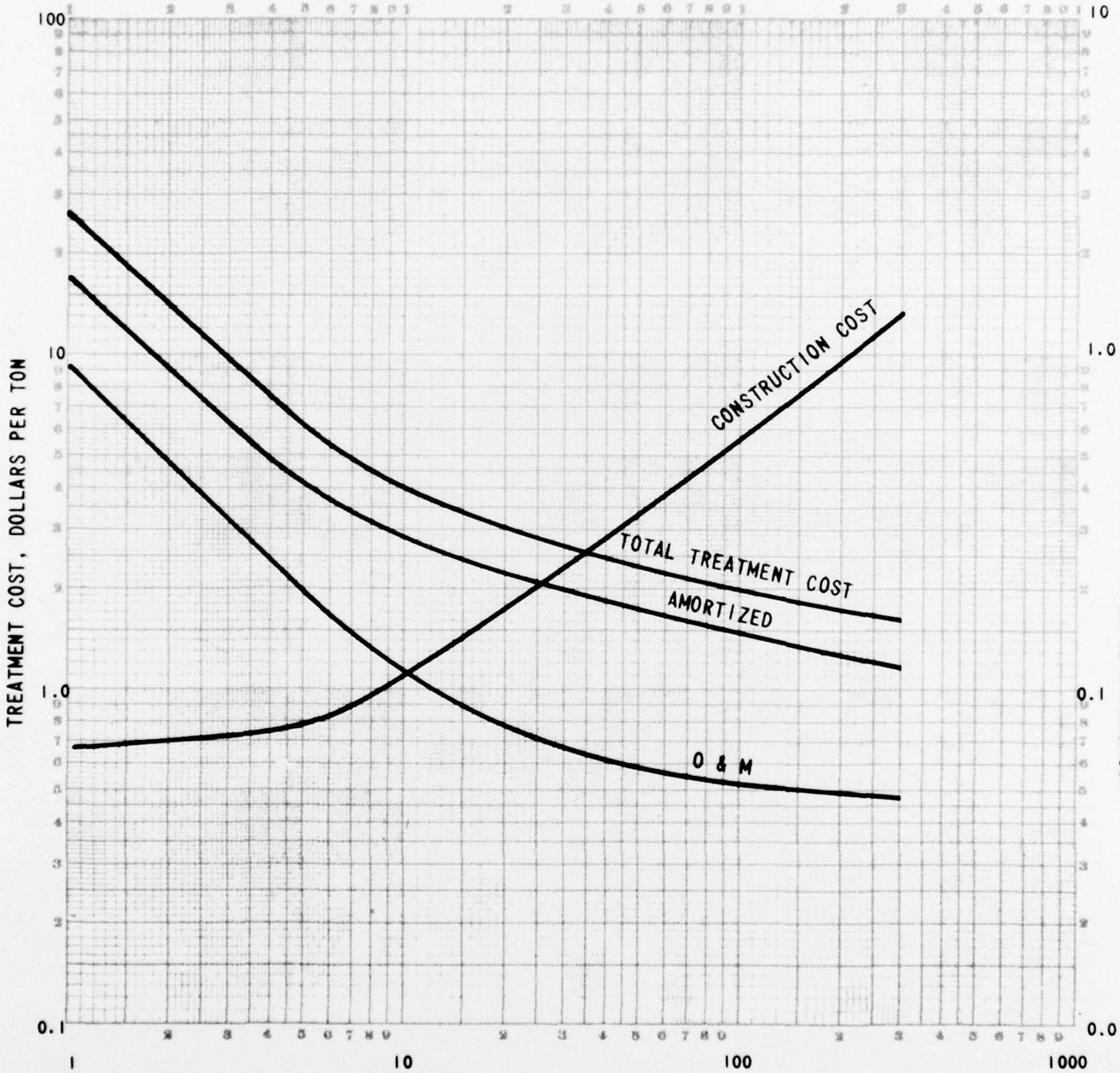
FIGURE A-17



FLOTATION THICKENING

COSTS BASED ON:

1. DETROIT, JAN., 1972. WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. POWER COST OF 1¢ PER KWH.
5. INFLUENT SLUDGE WITH A SOLIDS CONTENT OF 0.5%.
6. SURFACE LOADING RATE OF 14.4 LB/FT.^{2}/DAY.

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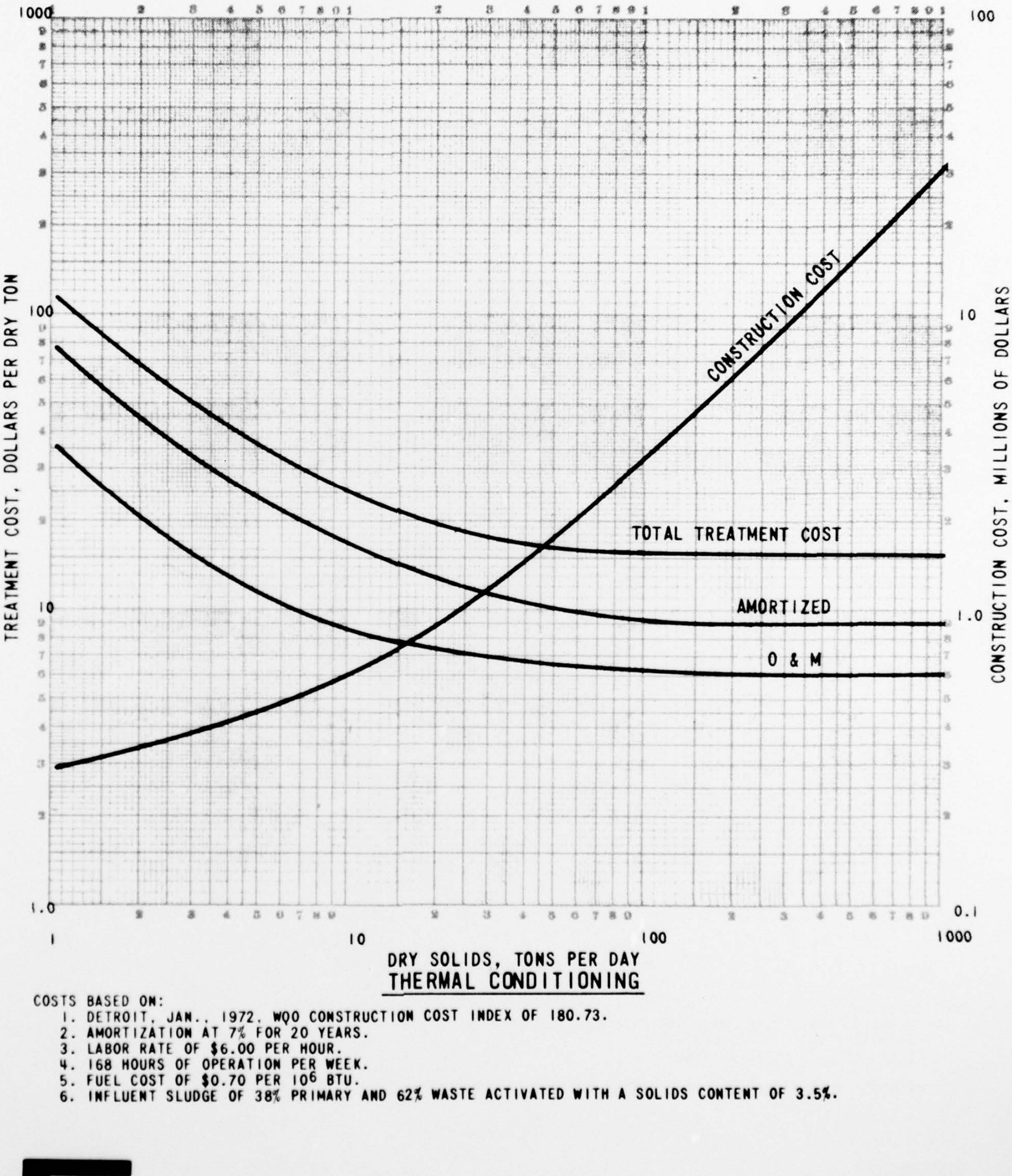
FIGURE A-18



THERMAL CONDITIONING

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. 168 HOURS OF OPERATION PER WEEK.
5. FUEL COST OF $0.70 PER 10^6 BTU.
6. INFLUENT SLUDGE OF 38% PRIMARY AND 62% WASTE ACTIVATED WITH A SOLIDS CONTENT OF 3.5%.

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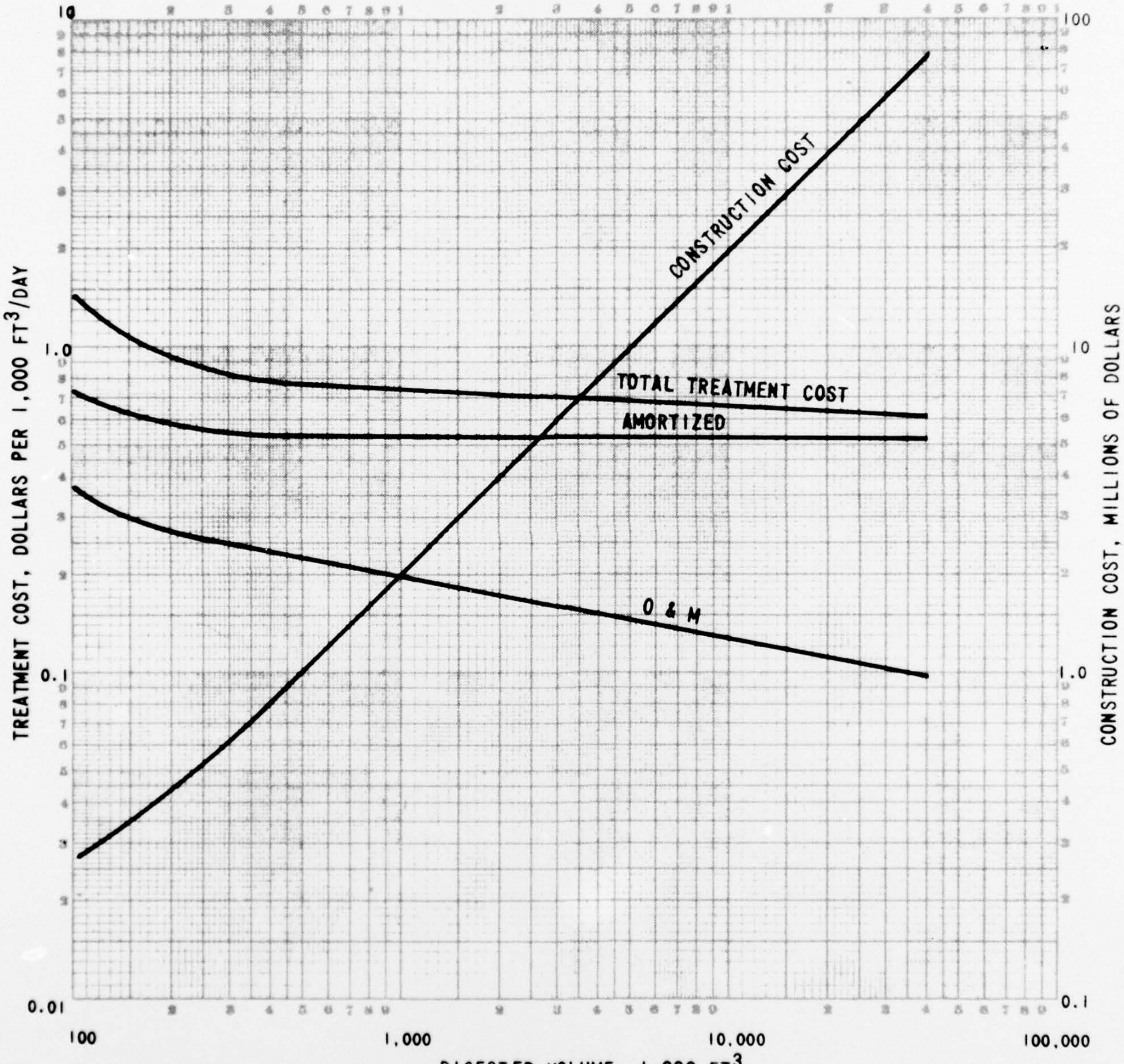
FIGURE A-19



ANAEROBIC DIGESTION

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.

COSTS INCLUDE: SLUDGE HEATING, CIRCULATING AND CONTROL EQUIPMENT.

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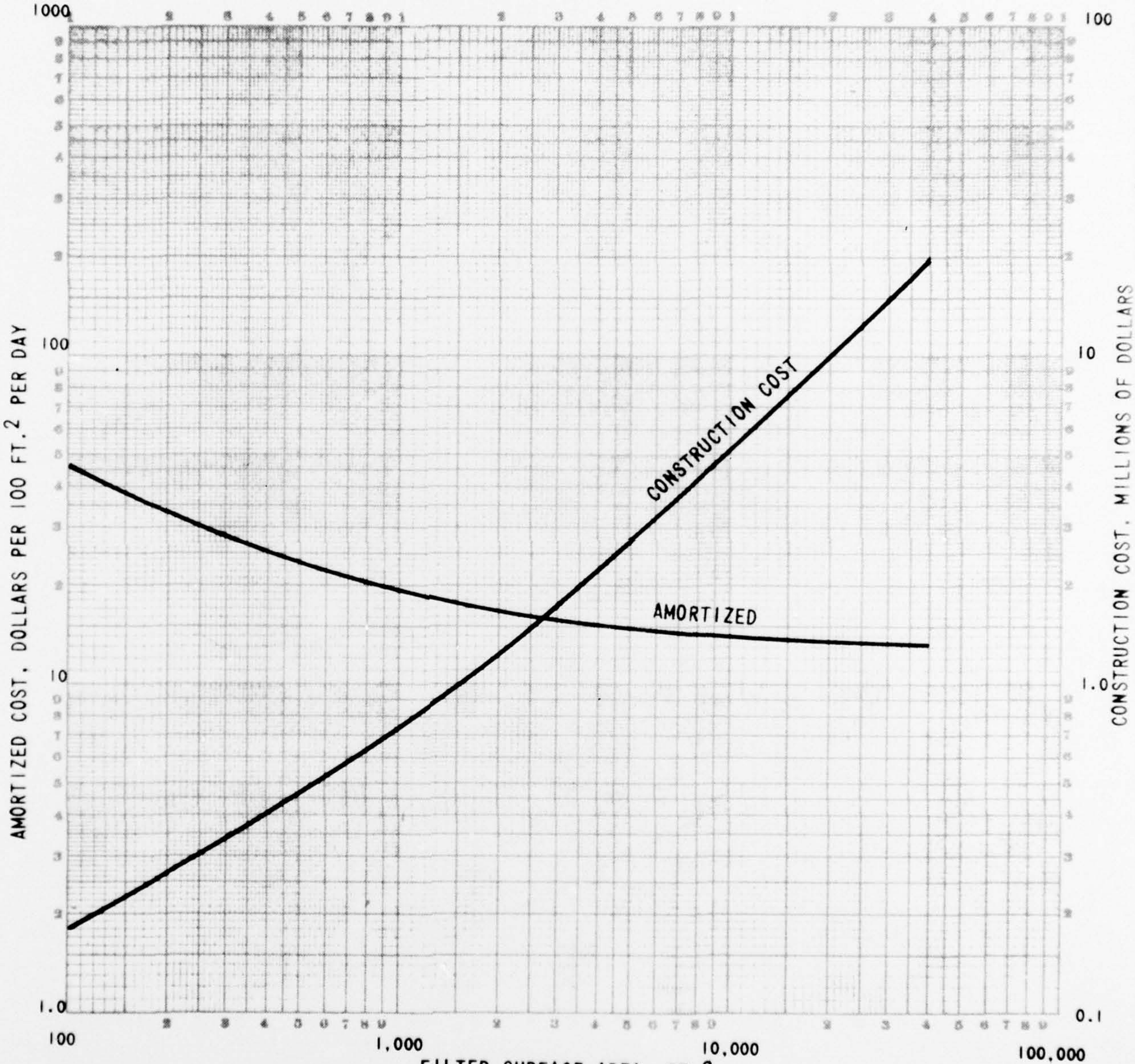
FIGURE A-20



VACUUM FILTRATION

COSTS BASED ON:
1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.

COSTS INCLUDE: ENCLOSING STRUCTURE.

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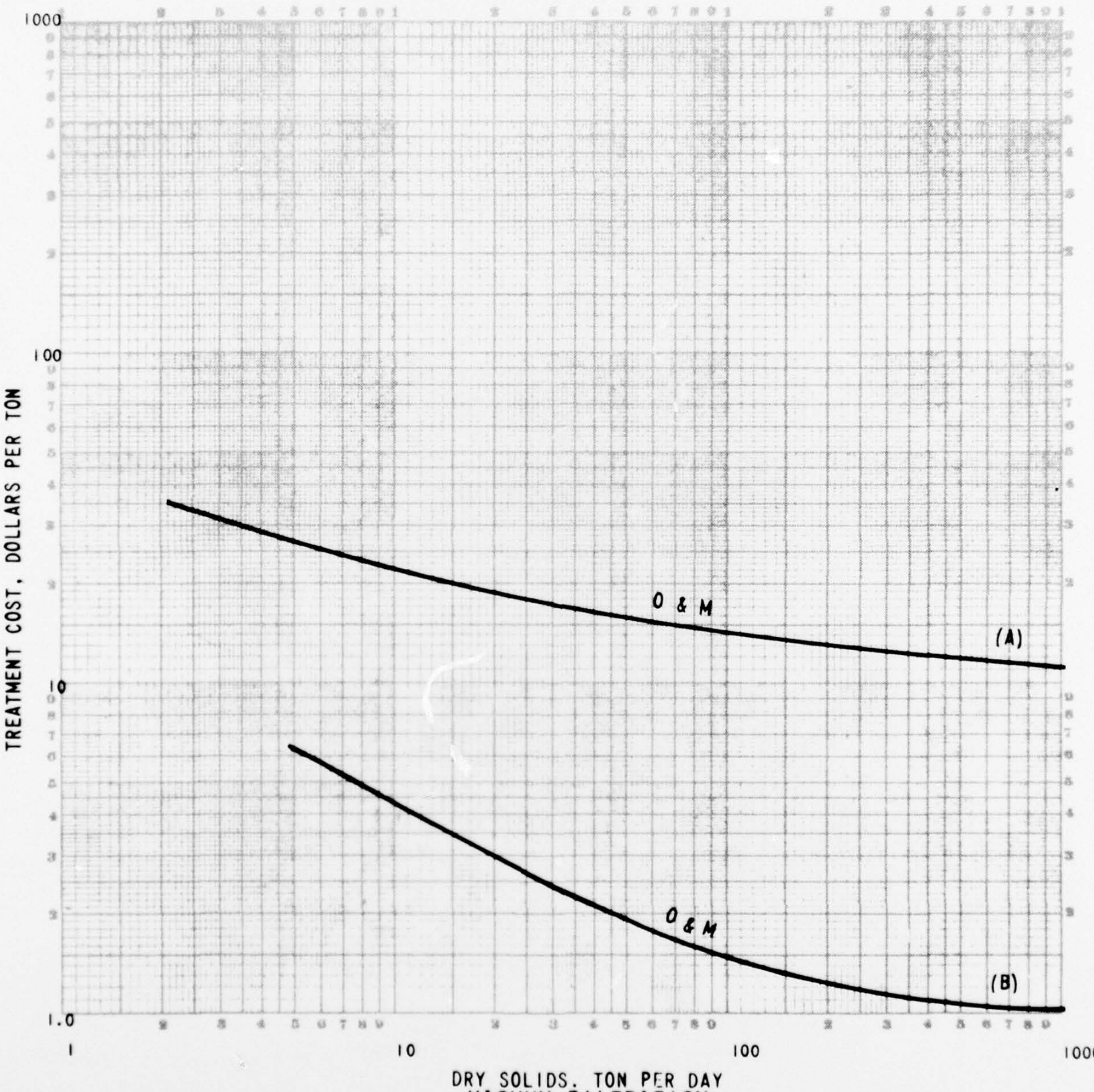
FIGURE A-21



VACUUM FILTRATION

COSTS BASED ON:
1. LABOR RATE OF $6.00 PER HOUR.

CURVE A - PRIMARY AND WASTE BIOLOGICAL SLUDGE WITH CHEMICAL CONDITIONING

CURVE B - CHEMICAL SLUDGE FROM LIME CLARIFICATION WITHOUT CHEMICAL CONDITIONING

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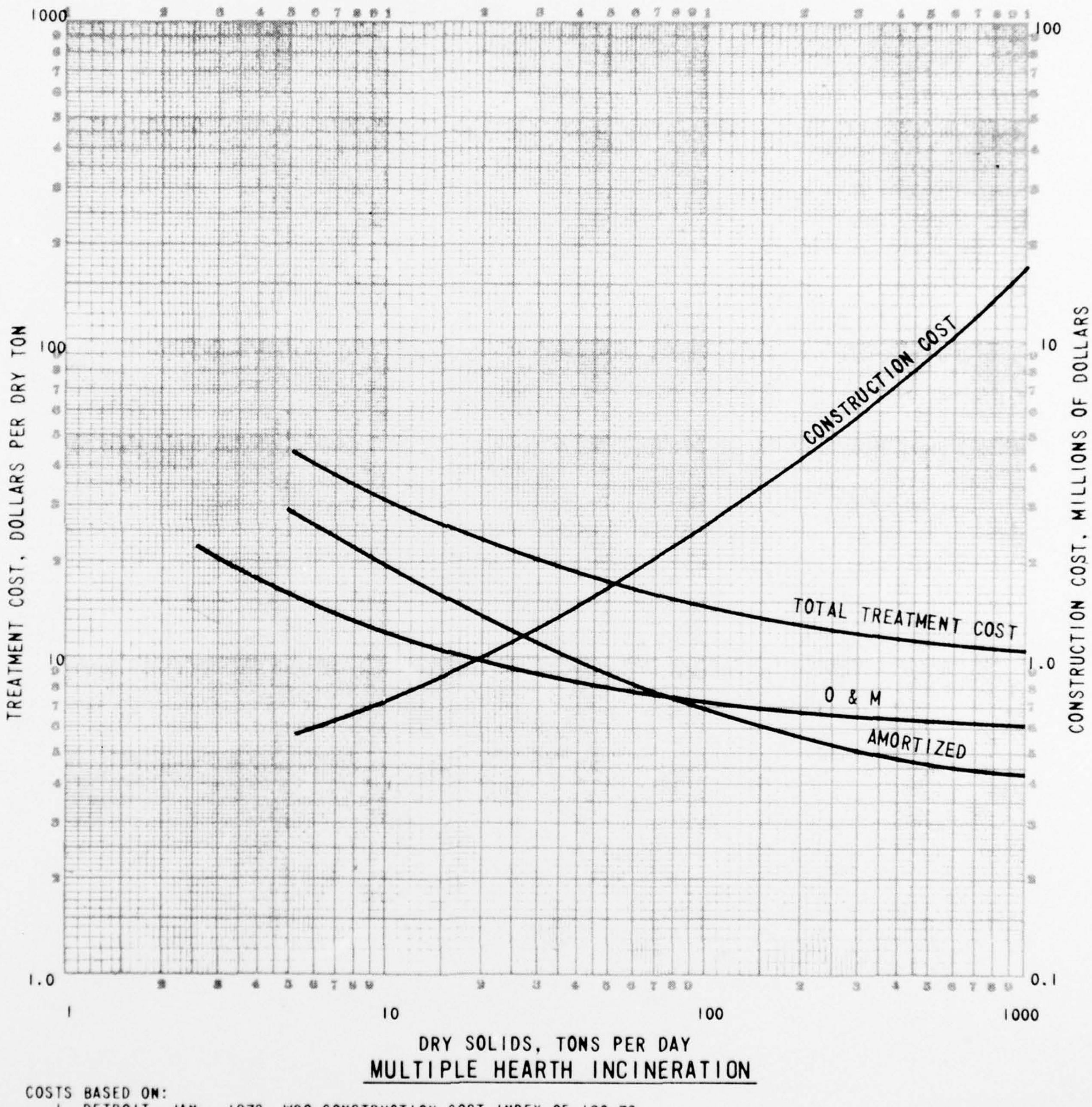
FIGURE A-22



MULTIPLE HEARTH INCINERATION

COSTS BASED ON:

1. DETROIT, JAN., 1972, WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.

COSTS INCLUDE: EXHAUST GAS SCRUBBER AND ENCLOSING STRUCTURE.

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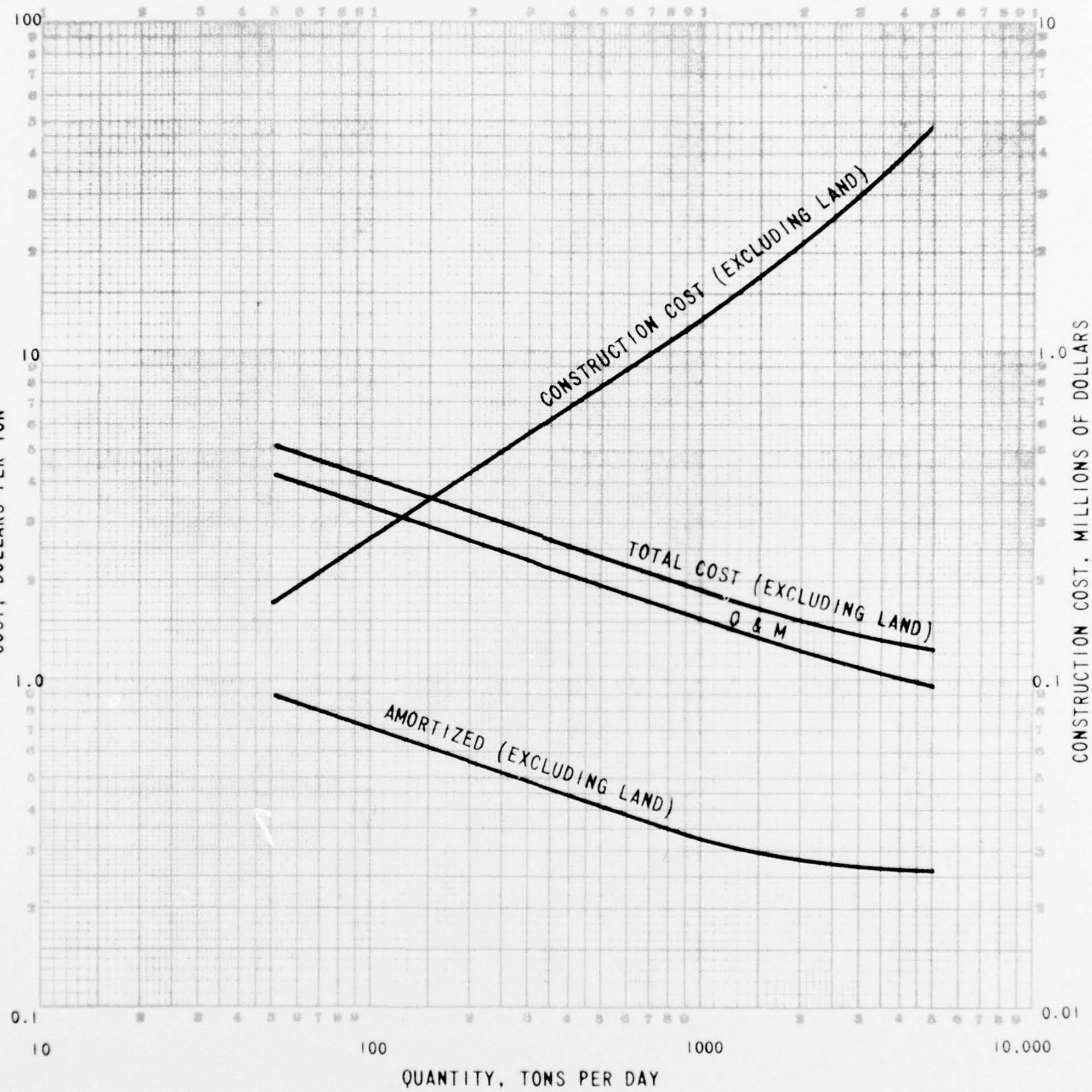
FIGURE A-23



SANITARY LANDFILL

COSTS BASED ON:
1. AMORTIZATION AT 7% FOR 20 YEARS.
2. LABOR RATE OF $6.00 PER HOUR.

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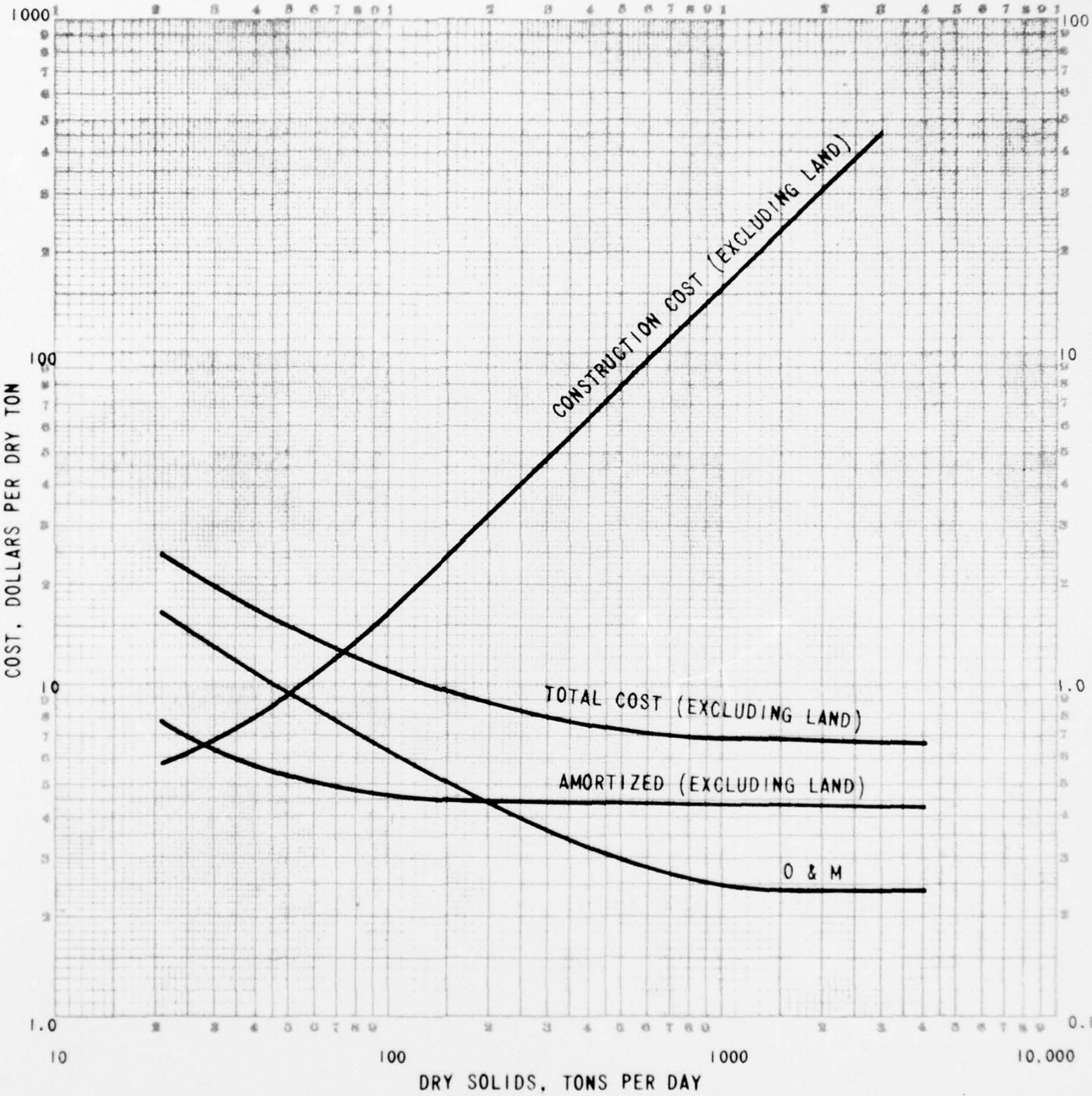
FIGURE A-24



SURFACE SPREADING

COSTS BASED ON:

1. DETROIT, JAN., 1972 WQO CONSTRUCTION COST INDEX OF 180.73.
2. AMORTIZATION AT 7% FOR 20 YEARS.
3. LABOR RATE OF $6.00 PER HOUR.
4. APPLICATION RATE OF 25 DRY TONS PER ACRE.
5. SLUDGE DILUTED TO A SOLIDS CONTENT OF 2% FOR SPRAY DISTRIBUTION.

COSTS INCLUDE: STORAGE LAGOONS, DILUTION WELLS, PUMPING STATION, PIPING AND SPRAY DISTRIBUTION EQUIPMENT.

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FIGURE A-25